Digital Debris:

Visualizing the Future of Global E-Waste

By

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of the requirements for the degree of Master of Design in Digital Futures

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Abstract

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Digital Debris: Visualizing the Future of Global E-waste
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A growing excess of electronic waste (e-waste) is being produced worldwide due to sudden changes in technology and media, falling prices of digital devices, and planned technological obsolescence. The focus of my thesis project is to create an immersive experience where audiences are confronted by the scope of, and the urgent need to better address, e-waste issues on a global scale. Using principles of critical design, I have created a series of vignettes that allow users to visualize the tangible and complex connections between familiar digital devices, and the overall lifecycle of e-waste.

Keywords: e-waste, virtual reality, immersion, 360 video, critical design, design futurescaping, speculative fabulation, postcolonial feminism, postcolonial ecocriticism, transcorporeality.

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Table of Contents

List of Figures

Introduction

A growing excess of electronic waste (e-waste) is being produced worldwide due to sudden changes in technology and media, falling prices of digital devices, and planned technological obsolescence. E-waste refers to all items of "electrical and electronic equipment (EEE) and its parts that have been discarded by its owner as waste without the intent of re-use" (StEP, 2018a). E-waste includes a wide range of products, from personal devices like laptops and cell phones, to household items like refrigerators. The United Nations Environment Programme (UNEP, 2015) classified e-waste into six different categories: temperature exchange equipment, screens, lamps, large equipment, small equipment, and small information and telecommunication devices. In short, almost any item with circuitry, electrical components, or a battery supply can be a potential source of e-waste.

The Global E-Waste Monitor (Baldé, Forti, Gray, Kuehr, & Stegmann, 2017) reported that the amount of e-waste produced worldwide in 2017 was 50 million metric tons, and that figure is expected to rise by 8% each year. One of the challenges of growing global consumerism–and as a result, growing waste–is that only 20% of global e-waste is recycled, and that e-waste accounts for over 70% of hazardous waste in landfills worldwide. Although those facts and figures are compelling, I believe that it is difficult for consumers, especially in the West, to conceptualize the severity of the situation, because so much of this waste is hidden from the mainstream.

The focus of my thesis is to make this hidden waste visible, and to create an immersive experience where audiences are confronted by the scope of, and the urgent need to better

address, e-waste issues on a global scale. Using principles of critical design, I created an immersive experience that allow users to visualize the tangible and complex connections between digital devices and the eco-political landscape of e-waste, now and in the future.

E-waste poses important ecological, political, and cultural challenges on a global scale, but I do not think that these challenges are being addressed with the urgency that is required. There is lots of information available online, and elsewhere, that detail the specifics of how much e-waste is produced worldwide, and what sorts of health and environmental consequences are related to e-waste (Goleman, 2009; Gabrys, 2011). Therefore, I argue it is not a lack of data, or even a lack of awareness, that is the issue. Rather, I think that there is a disconnect between the abundance of these facts and figures, and the accessibility and relatability of the data to consumers. This is in part because all waste, and e-waste is no exception, is hidden from consumers in their day-to-day lives. Thus, it is difficult to understand how we, as consumers, can and should change our behaviours accordingly.

In the context of this project, and with the recommendations I make towards advocacy efforts, I am specifically addressing consumers living in the West, in places like Toronto. Very few of us actually have seen landfills full of e-waste, or have water that is contaminated by toxic pollutants that come from e-waste, or know someone who forages through piles of old computers to extract microchips with their fingers. Because we have such little interaction with e-waste disposal, it becomes an abstract problem that affects "other" people, and this, over time, is a socially and ethically problematic stance. With a critique of this type of inequality in mind, I am using a postcolonial perspective to ground the theoretical framework of this project.

A postcolonial approach focuses on the consequences of the historical control of the Global North over the Global South, including the exploitation of colonized people and their lands (Mohanty, 2003). This also involves challenging assumptions about power, blame, and responsibility, and complicating movements like transnational trade and globalization. The brunt of the impact of e-waste is felt in the Global South, in countries like China, India, and Ghana, although these countries do not contribute a very high proportion of the production of e-waste (UNEP, 2015). The issue of e-waste disposal is an example of techno-colonialism, and imperialism by proxy, whereby the Global North outsources its problems, using the rest of the world as its dumping ground, without feeling much of the detrimental environmental or health impacts.

I take two main postcolonial positions in my research: an ecocritical one, and a feminist one. Vital (2008) describes postcolonial ecocriticism as a "politics and philosophy of environmental activism that is attuned to histories of unequal development, and varieties of discrimination, and contests the disparity between Western and non-Western cultures" (p. 90). Through a postcolonial feminist lens, I examine the specific ways that e-waste issues are gendered and racialized by focusing on non-Western contexts, including China and Ghana. Additionally, over 50% of my bibliography and creative references come from non-Western, non-male sources.

Current consumption practices in disposing of, recycling, and managing e-waste are not sustainable, and local and global policy solutions are vague at best. How can we develop

processes that make access to information about e-waste more affective, and how can we present it in a way that causes consumers to examine–if not change–their behaviours?

To investigate these larger questions, I first examined the material qualities, spatial relationships, and scale of e-waste. After gaining a comprehensive understanding of the physical nature of e-waste, I employed a critical design methodology to fabulate scenarios about e-waste. Finally, leveraging the affordances of virtual reality and 360 video, I created an immersive experience about e-waste that asks viewers to speculate on the future of digital devices, and the long-term impact of their consumption behaviours.

Context Review

Overview

Determining the scope of e-waste issues is complex. The production, consumption, and disposal of electronics includes a vast ecosystem of suppliers, consumers, and secondary economies. In order to contextualize the challenges, as well as the progress made towards addressing e-waste concerns, I began my context review by reading international policy and reference guides about e-waste, such as those published by the United Nations and the Institute for the Advanced Study of Sustainability (IAS).

In 2007, the United Nations Environment Programme (UNEP) created the Solving the E-waste Problem (StEP) Initiative, and they have since published comprehensive annual white papers and research reports. The StEP Initiative's mandate is to produce "sound solutions that reduce adverse impacts and support a circular economy [through a] systems-oriented governance structure." In StEP's 2016 report, they propose "international legislation, capacity building in developing countries, and redesign of electronic devices" as focus areas to combat e-waste production (p. 11). They provide links to their interactive World Map, where users can click on a country to see the total e-waste generated per capita, and the *Business Plan Calculation Tool for Manual E-waste Dismantling Facilities*, which "supports entrepreneurs in setting up an economically viable e-waste recycling business in an environmentally sound manner" (StEP, 2018a).

While I found StEP's reports useful to get a sense of how policy leaders and international non-governmental organizations understand e-waste, I did feel that their content was overly academic, and not particularly accessible to someone who was not familiar with jargon specific to ecological issues, nor did it give consumers information that was actionable. I also felt that their focus on "capacity building in developing countries" was a bit misguided, because the majority of e-waste is not produced in Global South countries, but rather in the Global North. Additionally, all of StEP's authors and project leaders are European or North American, and most of them are executives in large multinational technology companies like Philips and Dell (StEP, 2018b). I wonder how reformist and truly committed to overhauling the electronics industry StEP can be, when their advisory and managerial board directly contribute to the expanding e-waste industry.

For the purposes of disposal and waste management, e-waste is considered hazardous due to the presence of toxic materials such as arsenic, mercury, and lead (Gabrys, 2011). However, e-waste may also contain precious metals such as gold, copper, nickel, and rare valuable materials such as indium and palladium, which make it attractive to trade. While there is some legislation to curtail the international transport and sale of e-waste, it is still shipped and imported illegally. According to Rucevska et al. (2015), thousands of tonnes of e-waste that are declared as second-hand goods are regularly exported from the Global North countries to countries in the Global South; for example, waste batteries are often falsely declared as plastic or mixed metal scrap. In 2011, over two-thirds of the e-waste produced in the UK did not reach the recycling facilities it was designated to, but was instead shipped overseas (Lyons, 2016).

The reclamation of e-waste has several environmental implications. Un-recycled e-waste is dumped into landfills, incinerated, or shipped to countries in the Global South for resale. Dumping and incineration releases toxic chemicals and carcinogens into groundwater systems and the air, which can damage entire ecosystems. For example, *Waste Land* (Walker & Jardim, 2010) depicts the contamination of agricultural land and soil, as well as the degradation of plant life, as a direct result of e-waste. Additionally, e-waste pollutants in soil can have devastating effects on marine habitats and organisms, through groundwater runoff. These chemicals contribute to coral bleaching, abnormal growth and development of fish, and reduced aquatic oxygen levels (Paterson et al., 2006).

To better understand contemporary discourse about e-waste, I read many articles from global news sources and watched recently released documentaries (e.g. Journeyman Pictures, 2016; Vaatika, 2013; Fedele, 2012; SBS Dateline, 2011). These media detail the bleak recycling statistics, health concerns, and environmental implications of e-waste, complemented by textured, powerful visuals. After feeling inundated by all of this data, and over-stimulated by the confronting images of e-waste landfills, I began to think about why, when there is an abundance of information available about e-waste, there is still very little mainstream awareness from consumers about the issue.

Paradoxically, some of the most interesting and successful e-waste reduction initiatives have emerged from two very different groups: technology companies in Silicon Valley and e-waste pickers in the Global South. The following section describes some of these initiatives, and their respective strengths and weaknesses as solutions to e-waste issues.

Innovations

While there may not have been many consumer-led movements to tackle e-waste issues, there have been some innovations by technology companies in the last decade to try to combat electronic wastage, and to make electronics easier to recycle. One of those innovations is modular design. Modular design is an approach to production that allows the assembling and reconfiguring of universal parts into a variety of arrangements (Jones, 2016). The central premises of modular design are flexibility and innovation, facilitated by the (re)configurability of parts. The parts used, and thus the objects produced, can be physical or digital, new or recycled, standardized or customized.

Figure 1. Project Ara pre-release photo.
Reprinted from *Google delays its Project Ara modular smartphone until 2016* (Welch, 2015).

In 2015, Google created a prototype of a modular smartphone, known as Project Ara, whereby users could switch out LEGO-style components, that could be attached, rearranged, and swapped out in seconds (Figure 1). The project was initially proposed by Motorola in 2013, but Google bought the rights to the modular design project, and developed it for over two years, hoping to

roll it out for commercial release (Reisinger, 2015). Google cited a reduction in e-waste as one of the advantages of the Ara phone, imagining that users would be more likely to replace and (re)configure specific parts of their phones according to their preferences, rather than to buy a new device if its audio-jack stopped working or if the model's camera was upgraded. Unfortunately, Google suspended Project Ara in September 2016. It is disappointing to think that one of the largest global technology companies in the world gave up on this project, likely because it was not profitable for them.

In an attempt to address its own e-waste footprint, Apple has launched a series of Environmental Initiatives with the goal of "establishing a closed-loop supply chain" (Rujanavech et al., 2016), also known as a "cradle-to-cradle" or "zero-waste" supply chain. Zero-waste is a philosophy and practice where all discarded materials are designed to become resources for others to repurpose. It is an approach that encourages the redesign of resource life cycles so that all of the components of a product can be completely reused, recycled, or composted. The goal is for no trash to be sent to landfills or incinerators.

As part of the initiative, Apple created Liam, a design for disassembly robot, which is housed on its campus in California. Design for disassembly (DfD) is one method of creating a cradle-to-cradle supply chain. DfD is an approach to engineering and manufacturing that intentionally considers how the product, and all of its components, can be easily dismantled and repurposed at the end of its first useful life. According to its release notes, published by Apple (Rujanavech et al., 2016), "[Liam] utilizes a fully autonomous, clean take-apart process to liberate and separate individual components for speciality material recycling" (Figure 2).

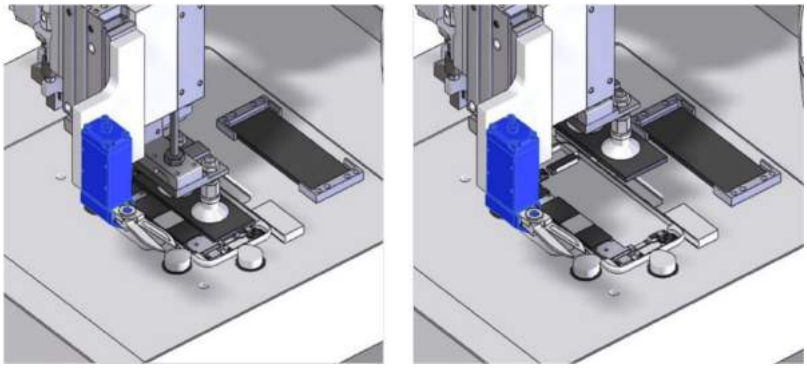


Figure 2. Liam dismantling process diagrams.
Reprinted from *Liam – An Innovation Story* (Rujanavech et al., 2016).

Using Liam as a case study could provide some insights and best practices for other technology companies to replicate. However, upon deeper inspection, Liam's model for recycling has quite a few limitations, primarily in scale. Firstly, Liam took three years, millions of dollars (Apple has not specified how much), and warehouse-sized spaces to build. It was also designed to specifically disassemble Apple products, with a focus on one smartphone model, the iPhone 6. Even if its blueprint was available on an open-source platform, Liam is unlikely to be rebuilt or replicated, due to lack of resources. Secondly, Apple products, and iPhones specifically, are only a fraction of the contributors of the global e-waste produced each year, and even if Liam was able to recycle each and every one of them, it would still not be enough. Liam cannot recycle each and every iPhone, at least not in a timely manner. In 2016, Apple sold over 220 million iPhones (Elmer-Dewitt, 2016). At the rate of disassembling 1.2 million iPhones a year (Rujanavech et al., 2016), it would take Liam 183 years to dismantle that year's batch alone.

So, this begs the question, is recycling the most efficient way of tackling e-waste issues? On the one hand, inventions like Liam help to localize e-waste issues, by providing opportunities to recycle iPhones close to where their owners used them, instead of exporting them to an e-waste

dumping site on the other side of the world. On the other hand, Liam was custom-built to dismantle only one type of product, so it is not easily scalable. Alone, Liam provides a singular solution, not a model or set of principles that can be replicated in other contexts, i.e. building a unique machine to dismantle every possible type of device is impractical. While it is possible that a more versatile machine could be developed to dismantle multiple products – which may be able to provide decentralized, regional solutions to waste – this would still not address the underlying issue of hyper-consumption of technology, which is the biggest contributor to e-waste.

Reduce, Reuse, Upcycle

Identifying and classifying electrical equipment and devices as waste can be difficult, as used or discarded electronics can be repurposed and still be of value to others. It is interesting to consider at what point something truly becomes "waste." Pongrácz and Pohjola (2004) define a thing as waste if it fulfills any of the following criteria:

> 1. It has no Purpose, either because
>   a. it has never been assigned one, or because,
>   b. it has not been assigned a new one after the first was fulfilled.
> 2. It is not performing in respect to its Purpose, either because,
>   a. a deficiency in its Structure, or,
>   b. it does not have the proper State (=functionality).
> 3. The owners failed, or did not use the thing for its assigned Purpose.
>
> (p. 145)

By this definition, electronics do not necessarily become e-waste as soon as their first owner or first user discards them. Rather, an item's useful life can be extended through handing it down to multiple successive owners.

One way to defer the process of electronics becoming e-waste, is to repurpose, or upcycle them. Upcycling is taking an item that is no longer needed or wanted and giving it new life as something that is either useful or creative (Goldsmith, 2009). Upcycling is the opposite of "downcycling", most commonly referred to as "recycling", where items are broken down into their component elements or materials. Once the constituent elements or materials are recovered, they are reused if possible, but usually as a lower value, less refined product. The advantage of upcycling is that the process of repurposing an item adds value to it, rather than detracting from it.

Upcycling is not a new phenomenon; communities in the Global South have found countless creative ways to repurpose items. These innovations can be as simple as cutting up old clothing to use as washcloths, to more complicated projects that repurpose plastic confectionary wrappers into bricks to build shelters (Ghani, 2016). However, the scale of upcycling in these contexts has been limited, and were created as responses to immediate needs, rather than as environmental policy. However, there is potential for these types of innovations to expand their reach, and in the case of e-waste, many African countries have taken the lead (Vallauri, 2009).

Makerspaces in Togo and Ghana are pioneering ways to upcycle electronic materials, and are creating best practices that can be applied in other contexts. WoeLab is a Togolese makerspace founded in 2012, whose mandate is to create sustainable technology, through locally sourced materials, to help promote urban renewal within the nation of Togo (Ungerleider, 2013). In 2013, Kodjo Afate Gniko, an inventor at the WoeLab makerspace, created the world's first 3D-printer

created out of discarded e-waste (Figure 3). Afate used open-source instructions posted on GitHub to create his printer, named W.AFATE, and modified the list of materials to fit what was available locally. His design has seen been replicated, including within Togo to create a miniature 3D printer (Koslow, 2016), and in Tanzania at the Buni Hub fabrication lab (Buni, 2018).

Figure 3. Gniko with W.AFATE.
Reprinted from *This African Inventor Created A $100 3D Printer From E-Waste* (Ungerleider, 2013).

The world's biggest e-waste dump, in Ghana, is also home to an innovative makerspace. The Agbogbloshie Makerspace Platform (AMP) sees its location as an asset, explaining on its website:

> Whereas others reductively denigrate Agbogbloshie as a toxic e-waste dump, we see instead an urban-scale open-air manufactory—an action-oriented maker ecosystem where materials and components reclaimed from end-of-life equipment feature as inputs for making new products. The environmental challenges are huge, but Agbogbloshie is an amazing model—a distributed network of makers recycling the city at the grassroots. AMP aims to learn from Agbogbloshie, in order to amplify its potential as a model of micro-industrial ecosystems for broader application (AMP, 2018).

Inventors at AMP were able to create computers made out of e-waste materials and water canisters (Ottaviani, 2015). Their design may have been inspired by Jerry DIT, a transnational project that provides open-source guidelines on how to build a computer out of an upcycled jerry can. Jerry DIT has a downloadable, easily understandable instructional PDF that has been used to create these computers in Algeria, Benin, Mali, Côte d'Ivoire, Togo, and Cameroon (Jerry DIT, 2018).

Another approach to upcycling e-waste is through creating artwork and crafts. For example, E-lab is a Kenyan start-up that "aims to tackle the growing issue of e-waste in Africa by transforming it into art, fashion, and accessories" (Kalan, 2014). E-lab's creations include sculptures made out of wires, and notebooks bound by circuit boards. Other innovators in this field include Gladys Muyenzelwa, a Batswana fashion designer who has been creating ethnic and contemporary clothes, accessories, and furniture out of discarded electronics (Churu, 2015), and Cyrus Kabiru, a Kenyan artist who creates eyeglasses and wearables out of e-waste (Sierzputowski, 2015, Figure 4). Large international companies, such as Dell Technologies, have also participated in the upcycling trend. In 2018, Dell launched a jewellery line with actress Nikki Reed, that uses reclaimed gold from discarded computers (Bayou With Love, 2018).

While it is important that these upcycling initiatives are gaining prominence, the issue of scalability remains a challenge. Creating technical machinery and artisanal pieces from e-waste requires creativity and highly skilled workers. Each upcycled piece is custom-made and one of a kind due to the uniqueness of the materials available to its creator. Having open-source instructions on how to recognize reusable materials, and how to repurpose those parts for other

creations, is very useful. However, it is unlikely that the average consumer will be inspired to upcycle their own e-waste into 3D printers or create sculptures out of discarded electronic components, which limits the extent to which upcycling can be a practical solution to reduce the spread of e-waste worldwide.

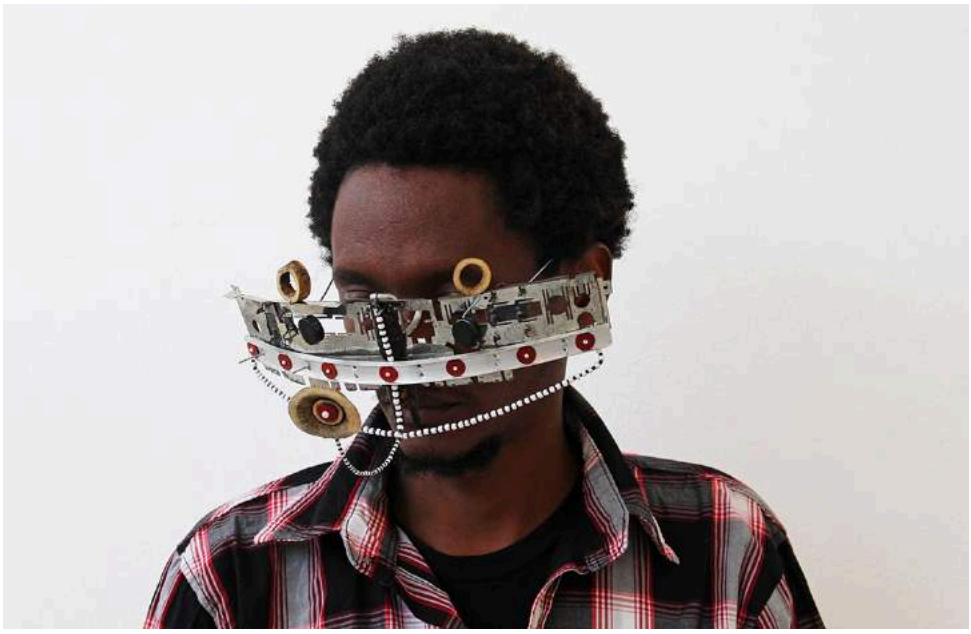


Figure 4. Kabiru's e-waste eyewear.
Reprinted from *Kenyan Artist Digs Through Electronic Refuse and Found Metal to Create Dazzling Sculptural Eyewear* (Sierzputowski, 2015).

Creative Works Review

E-waste has been reused and upcycled in many artistic and practical ways. To situate my prototype within a larger context of creative works about waste, I looked at art and design pieces that have incorporated electronics, explored issues of material excess, and have commented on the politics of waste.

Many artists, including Elias Sime, Lee Woo, Franco Recchia, Anna Sew Hoy, Barry Ace, and Taezoo Park have used e-waste in their work, either as a medium or the subject matter of their pieces. There have also been film and documentary works about waste, such as *E-wasteland* (2012), *The Toxic E-waste Killing Pakistan's Poorest* (2016), and *Isle of Flowers* (1989), that help to frame the issue of waste production and disposal within a larger social and cultural context. Additionally, architects, urban planners, and designers have also tried to create structures to curtain the spread of e-waste, and transform the ways in which waste collection sites function across geographic spaces (Engler, 2004; Parikka, 2011; Lateral Office, 2017). The following examples are an abridged selection of creative works that guided the development of my prototype.

Sculpture

Electri-City Mountain is a series of miniature cityscapes made from recycled circuit boards, LEDs, and a plasma plate. According to the artist, "these pieces conjure an image of a future society built from what we throw away. Utopian or dystopian, the *Electri-Cities* are as entrancing

as they are intricate and will draw people back again and again," (Yates, 2014). I think that these pieces provoke questions and conversations.

Figure 5. Photo of Electri-City sculpture.
Screenshot from *Electri-City Mountain* (Yates, 2014).

A recurring visual in Yates' sculptures are colorful LEDs, which are reflected by metallic components of the wires and circuit boards around them (Figure 5). The LEDs are the only light sources in his sculptures, and are vivid, artificial colors, like purple and neon green. If I imagine myself living in one of Yates' cities, with only the glow of LED lights to navigate my way around, they begin to take on a more ominous quality. The LEDs make me think about the long-term consequences of e-waste on the environment, like radiation: even if the pollutants are not visible, they leave a trace.

What I like about these pieces is the way that Yates was able to repurpose e-waste in such lively and vibrant ways. I read this project as speculative and inspired by science fiction, because it

compels audiences to think of the future, of the consequences of waste, and how consumers are implicated in this process. While Yates' rendering of a future made of waste is beautiful, I do not believe that our actual future will be. However, I do like the way that Yates used the materiality of the e-waste, for example, imagining buildings made out of discarded computer parts. It made me consider whether I would like to live in a building constructed with old modems and CPUs one day, and consider the societal and cultural consequences of living in that sort of environment.

Film

Solid Waste is an immersive documentary, installation, and speculative fiction piece about the present and future of waste disposal in Canada. King (2015) describes the purpose of the documentary as "presenting as an invitation to contemplate the matter we go to great lengths in making invisible." *Solid Waste* documents behind the scenes at six sites of waste disposal in Toronto. There is a tension in this piece between the sheer volume of waste, and the fact that there is a pleasing aesthetic value to the way that it has been presented (Figure 6). While viewing the documentary, I was overwhelmed, but also captivated, by the vastness of the waste. It was hard for me to fathom that this was documented in Toronto, and how oblivious I am to the process of waste disposal in my own city.

I am interested in King's methodology of speculative writing, which inspires some of my own work. King's piece effectively communicates the enormity of waste, which is a critical aspect of my own prototype. I find the most important aspect of this work is the questions it asks about

waste: what is waste, when does something become waste, where does waste go, and why do we hide waste?

Figure 6. A pile of garbage in a Toronto landfill.
Screenshot from *Solid Waste* (King, 2015)

Another film that inspired my work was *The Gleaners and I* (Varda, Bruzdowicz, Ciné Tamaris & Zeitgeist Films, 2002). This documentary follows different communities of gleaners as they scavenge for food and other materials in urban and rural contexts. The film provides insights into a large context of waste picking, across different geographies and conditions, as well as the individuals and micro economies that are dependent upon gleaning.

The Gleaners and I highlights the nuances within the material excess of waste. Varda et al. (2002) challenge viewers to see the value in the surplus of crops, trinkets, and garbage, rather than the unpleasantness. While gleaning has traditionally been associated with poverty and desperation, the film shows that there is a long legacy of gleaning in France, and that it is a

practice that many partake in with dignity and pride. Interviewees in the documentary describe the sense of empowerment that they feel through gleaning, because it allows them to have agency in times of difficulty. These individuals explain that they feel a sense of independence through being able to provide for themselves and others through gleaning, and that they experience a freedom in harvesting valuable items from others' unwanted stock. This is an important perspective that is often excluded in discussions about waste and those who rely upon gleaning for their livelihood.

Lora-Wainright (2016) describes a similar phenomenon in her interviews with e-waste collectors in China. Despite the harsh environmental conditions of living and working in e-waste dumps, these collectors oppose government intervention or regulation in this field. Interestingly, the locals refer to the e-waste collection site as Treasure Town, whereas outsiders see it as a dump. They explain that through collecting e-waste, they are able to be self-sufficient and work for themselves. By selling their harvest directly to recycling companies, instead of working for an intermediary, they are able to yield higher profits, and have even been able to afford starting their own businesses or buying the land that they previously scavenged upon. I think that it is important to acknowledge that the dominant perspectives about gleaning can often be quite patronizing and oblivious to the potentially advantageous aspects of waste.

Varda makes herself a protagonist in the film. She describes the experience of filming with one hand and gleaning with the other, as essential to her process of understanding the practice of gleaning. I like the way that Varda places her physical body as a character in the work, to emphasize the way that she is a participant in the larger, metaphorical ecosystem of gleaning

through her artistic practice. I am inspired to make a similar statement in my prototype to show that I see myself, and my technological consumption habits, implicated in the global problem of e-waste.

Design

Geographies of Trash is a sculptural installation that visualizes data about trash disposal, collection, and storage in Michigan. It maps out the spatial relationships and transportation routes involved in the current management of waste, as well as speculative architectural designs for how trash could be managed more effectively.

The installation consists of a large cube, made up of an aluminum skeleton and layers of acrylic surfaces (Figure 7). Each side of the cube represents the scale of a township, which is covered by a translucent map of the area. The sites of Ghosn and Jazairy's proposed projects within each township are modeled in yellow resin. The designers explain, "by making trash visible and formal, the project aspires to engage both disciplinary and public debates on waste systems" (Ghosn & Jazairy, 2015).

What I like about this piece is that it follows a speculative design methodology. It presents a scenario that is familiar to its audience, but it also transforms a space and asks viewers to be critical. Additionally, the installation creates a tactile experience between the viewer and the work. Every element of the research is visualized in a tangible format, which allows people to engage with it on a theoretical, practical, and sensory level. I am inspired by the layers that are

visible in this piece, from the more obvious structural components, to the translucent panels and 3D cast elements.

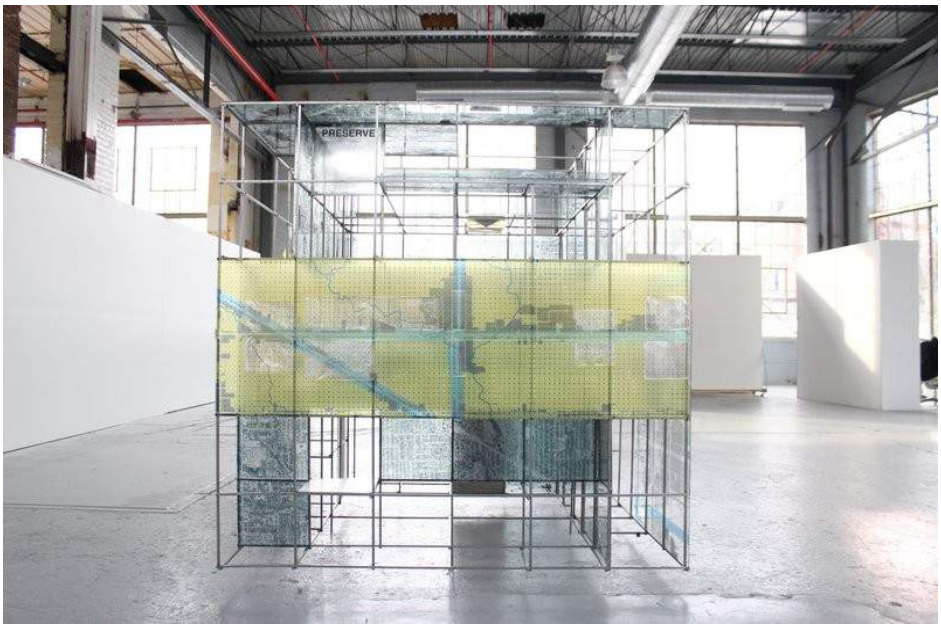


Figure 7. Installation photo of Geographies of Trash.
Reprinted from *Geographies of Trash* (Ghosn & Jazairy, 2015).

All of these creative works provide insight into the ways that waste, as a theoretical and material phenomenon, can be visualized and expressed. Through a survey of these works, I was able to gain a more holistic understanding of the ways that artists have explored differing perspectives about waste, and how they created a relationship between their concepts and viewers of their work. All of these pieces made me feel involved in the work, either because of the compelling narrative that was presented, or because of the aesthetic qualities that encouraged engagement with the work.

Immersion

An explicit way to make viewers feel involved with the work is through the use of immersive technologies. Immersion, as a concept, can be described as a "spatial, 3D experience of imagery and sound…which can be kinesthetically explored by others through full body, real time interaction" (Davies, 2004, p. 69). Immersion through digital technology can be experienced using immersive virtual environments (IVEs) such as virtual reality (VR) and augmented reality (AR).

Digital immersion is a technique that can be leveraged to promote actionable change in viewers. Ahn, Bailenson, and Park (2014) investigated the effects of IVEs, and embodied experiences, on behaviour change. They defined IVEs as those that allow individuals to see, hear, and feel digital stimuli as if they were in the physical world. IVEs have strong emotional valence, which increases the personal relevance of an individual's experience. In their study, Ahn et al. (2014) used VR technologies to create IVEs. They found that having individuals actively engage in and perceptually experience these immersive scenarios heightened their "internal locus of control" (p. 236), by emphasizing the fact that their individual actions directly impacted their environment. By making the connection between their behaviour and consequences explicit, the researchers in this study were able to manipulate individuals' emotional responses.

Through the IVEs in the study, individuals saw, heard, and felt the negative future consequences of their present actions as if they were occurring in the moment. For example, individuals were able to viscerally experience their contribution toward deforestation by experiencing a VR

simulation where they would actively engage in cutting down a tree. The researchers found that VR effectively reduced the cognitive distance between the individual's behaviour (cutting the tree), and the consequences of the simulation (an environment of deforestation). They found that individuals in their study who experienced the simulation were more likely to report wanting to take action to mitigate deforestation than those in a control group. Thus, there is evidence to support the use of IVEs as a motivating factor towards behaviour change.

Virtual Reality

VR creates a three-dimensional (3D), simulated environment that places the viewer inside an experience (Murray, 2016). Using a head mounted display or headset, the VR environment becomes an immersive space to be visited and navigated through. Nonny de la Peña is one of the pioneers of VR storytelling and filmmaking. In her TED talk, she asks,

> What if I could present you a story that you would remember with your entire body and not just with your mind? With VR, I can put you on scene in the middle of the story. By putting on these goggles that track wherever you look, you get this whole-body sensation, like you're actually there (de la Peña, 2015).

de la Peña (2015) has created VR experiences, that play out like short-films, by using audio from real situations and then building the 3D visuals using digital tools. For example, she and her team were commissioned by the World Economic Forum to create a piece that raised awareness about the plight of Syrian refugee children, in parts of Iraq that are under the control of ISIS. They used real video clips as source material, and then recreated the video's environment in VR. The piece, *Project Syria*, was displayed in the Victoria and Albert Museum in London, and received an enthusiastic, emotional reaction from viewers.

de la Peña (2015) argues:

> This stuff works...it's really evocative. I'm not saying that when you're in a piece you forget that you're here. But it turns out we can feel like we're in two places at once...and I think that's what allows me to tap into these feelings of empathy.

She explains that viewers feel strong emotions in reaction of these types of experiences, because they feel directly implicated in what is happening in the VR world. She suggests that there is great potential for using VR in journalism, as well as a tool to create deeper engagement and understanding from viewers.

360 Video

While VR pieces have typically been created using digital technologies and video-game engines, 360-degree (360) videos are a new tool available to create immersive visual experiences. 360 cameras are now able to record detailed footage, whereby viewers are able to experience a three-dimensional panoramic scene, and feel as though they are situated within the shot. 360 videos are created by multiple camera lenses filming overlapping angles simultaneously. Through a method known as video stitching, this separate footage is merged into one spherical video piece (Graham, 2016).

Milk (2015) describes a similar effect of engagement to de la Peña (2015) that he was able to achieve using 360 video. Milk directed *Clouds Over Sidra*, a film that tells the story of a Syrian girl named Sidra, and her life in a refugee camp in Jordan. He explains:

> When you're inside of the headset...you're looking around through [her] world. You'll see a full 360 degrees. And when you're sitting there in her room,

> watching her, you're not watching it through a television screen, you're not watching it through a window, you're sitting there with her. When you look down, you're sitting on the same ground that she's sitting on. And because of that, you feel her humanity in a deeper way. You empathize with her in a deeper way (Milk, 2015).

I experienced the powerful and persuasive qualities of 360 video for the first time after viewing *Very Frustrating Mexican Removal* (Uzun, 2017). Uzun used 360 video and verbatim theater to recreate the context and visuals surrounding the death of Lucia Vega Jimenez, a Mexican migrant detained at an immigration centre in Vancouver, in 2014. I found her technique very effective, as it allowed a combination of forensic re-enactment, as well as some artistic interpretation in the visuals. Uzun was able to create a highly emotional storytelling experience using very minimal aesthetics. Each scene in her video was a landscape of somewhere that Lucia had been before she died: a train station, a forest, and finally the bathroom of the detention centre.

Uzun's video was able to provoke a very strong, visceral response from me, as I felt that I was there, experiencing Lucia's death first hand as the story was being played out in my VR headset. I had to take off the headset halfway through the video because I felt so sad and angry at what I was viewing. While the narrative itself was compelling, I think that the reason I felt so emotionally invested in the piece was because it was immersive, which meant that I felt somewhat implicated with her death. While the scope of my project is different, I hope to leverage some of the same affective qualities as Uzun and make audiences feel similarly implicated in the narrative of e-waste.

Immersion is a central concept to my project, as it helps to merge the core ideas of my research with the practical affordances of my prototype. The following section outlines the theoretical framework of my project, which I used to analyze some of the key social and political issues in the e-waste sector. Through this process, I was able to operationalize these concepts in my creative designing and making process.

Theoretical Framework

The critical framework of this research is rooted in postcolonial theory. Postcolonial theory takes into account the ways that racism, in addition to political, economic, and cultural effects of colonialism, affect non-white, non-Western people on a global scale (Mohanty, 2003). It takes a particular focus on the continuing damage that Euro-American imperialism and consumer capitalism has inflicted on people in the Global South. To contextualize my research within a postcolonial framework, I first examined discourse about e-waste through an ecocritical lens, and then considered some of the social and political implications of e-waste through an intersectional feminist lens.

Ecocriticism examines the relationships between humans, animals, and the environment, while postcoloniality emphasizes the ways that imperialist values have shaped our contemporary understanding of these relationships (Pellow, 2007). Huggan and Tiffin (2006) explain that "postcolonial ecocriticism is paradoxically driven by the impossibility of its own ambitions: to make exploitation and discrimination of all kinds, both human and not, visible in the world, and in doing so, help to make them obsolete" (p. 16). They argue that the mainstream ideological divide between humans and nature emerged due to the anthropocentric values that were spread by Euro-Christian colonial rule.

According to anthropocentric logic, human beings are the most significant entity in the universe, and the categorization of a civilized society is dependant upon the degree to which humans have control over nature. Thus, many non-Western societies that closely relied on their environment to

meet their physiological and spiritual needs were deemed barbaric and morally inferior under this definition. Huggan and Tiffin (2006) argue that, "in a Western context, it has been more difficult to exalt the environment… which has been regarded as a mere backdrop against which human lives are played out" (p. 20). Postcolonial ecocriticism challenges the way that Eurocentric definitions and systems of power have framed human understandings of the environment.

In my project, I use postcolonial ecocriticism and feminism to problematize dynamics of ownership and responsibility between humans and the environment. I disagree with anthropocentrism. Rather, I believe in biocentricism, an ethical perspective that argues that all living species have inherent value, and that humans are not superior to other organisms (Pellow, 2007). The following intersectional analysis takes into account the ways that human relationships to the environment are gendered and racialized.

Gender, Race, and Labour

To ground my analysis of e-waste within a holistic postcolonial framework, I integrated an ecocritical perspective into my feminist analysis by acknowledging that environmental factors affect all structures of power. By looking at cross-cultural examples, I first investigated the ways in which e-waste issues are gendered and racialized. I then drew on the theoretical concepts of Stacy Alaimo's transcorporeality (2008; 2010; 2013; 2016), and Donna Haraway's cyborg identity (1991; 2016) to situate my research within a critical feminist discourse about matter and futurity.

A comprehensive gendered analysis can be applied to the topic of e-waste, starting from the production of electronic devices until the process of re/upcycling. As a result of an increasingly globalized economy, opportunities for women's employment in manufacturing sectors, notably in electronic component assembly, have increased dramatically over the last 50 years. For example, in Malaysia, over 90% of all electronics manufacturing jobs are occupied by women (Jomo, 2013). Mainstream discourse has focused on how this employment has been empowering as it allows women greater levels of economic mobility. However, this perspective overlooks the disparity between male and female workers who enter such jobs. Men in the same industries are generally given superior positions, and their roles are less tedious and labour-intensive than women's (Hester, 2016).

> The construction of women as a source of low-cost flexible and efficient labor is frequently a deeply racialized process – drawing upon ideas of 'Third World' women as well suited to the monotonous working conditions found in some of the most globalized sectors of the world economy (Elias, 2010).

Many multinational companies specifically want to employ 'third-world' women because of their perceived "innate" skills of dexterity, patience, obedience, and docility (Elson & Peterson, 1981). A quick search on YouTube will pull up thousands of videos of young women, mostly in factories in China, assembling complex circuits within a matter of seconds (antttttttttt, 2008). This work is highly skilled, difficult, and tiring. However, these female workers are underpaid, and exploited by their employers because of their subordinate position, compared to their wealthy, often Western, employers. Their relative status is moderated not only by gender, but by race, class, and nationality.

A similar criticism can be applied to the racialized nature of employment in the electronics industry. In the 1960s, Fairchild Semiconductor International, a pioneer in the manufacture of transistors and microchips, opened a semiconductor assembly plant on a Navajo reservation in Shiprock, New Mexico. The majority of workers in this plant were Navajo women and, in their 1969 annual report, Fairchild describes the work of building semiconductors as a "labour of love" (Nakamura, 2014, p. 938). The report inferred that semiconductor assembly was akin to the production of indigenous cultural crafts because of the visual resemblance of the wiring of electronic chips to traditional, rectangular Navajo rug patterns (Figure 8). A manager at the Shiprock assembly plant described the "untapped wealth of natural characteristics of the Navajo... the inherent flexibility and dexterity of the Indians... after years of rug weaving, Indians were able to visualize complicated patterns and could, therefore, memorize complex integrated circuit designs," (Nakamura, 2014, p. 926).

While the Navajo workers were very successful at their jobs, and the introduction of technical jobs to the community had economic benefits, one of the biggest incentives for Fairchild to open their plant on a reservation was because of the immobility of the workforce. Unlike in other parts of the U.S., where employees could be part of labour unions and protest their working conditions, the Navajo employees would not relocate, because of their (contemporary and) ancestral connection to the land. The Fairchild brochure explained the value of this for both Fairchild and the U.S. government, who wanted to eliminate federal support to Native Americans, stating "the real value of this progress lies in the creation of meaningful jobs... which will keep them in the land they love and among the people they know" (Nakamura, 2014, p. 933).

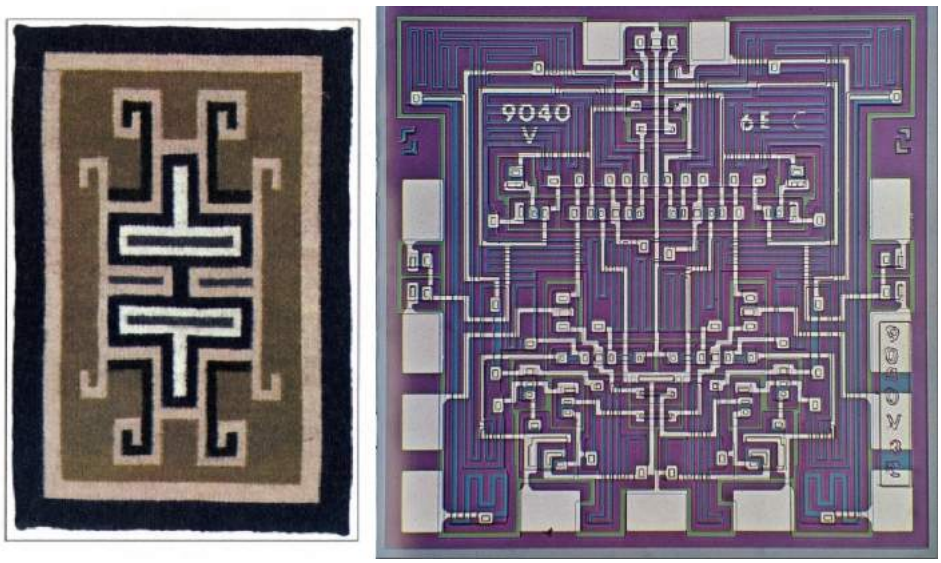


Figure 8. Comparison between Navajo weaving pattern and circuitry in a Fairchild microchip. Reprinted from Indigenous Circuits: Navajo Women and the Racialization of Early Electronic Manufacture (Nakamura, 2014).

Discrimination based on race and gender is also salient during e-waste disposal. Women and children tend to be concentrated in the most exploitative segments of e-waste work (Lines & Garside, 2016). Women who work in the e-waste disassembly sector use crude tools, if not their bare hands, to extract the reusable components of e-waste, and are often designated the most undesirable and dangerous tasks, including using acid baths to reclaim precious metals (Wong et al., 2007). In Ghana, children as young as 5 years old have been reported to be involved in the collecting, sorting, dismantling, and burning of e-waste materials (Osibanjo, 2015).

Women's and children's health are disproportionately affected in the e-waste sector, since it is they who often assume the lowest-tier jobs, and are the groups most vulnerable to health risks from exposure to e-waste. A study on the effects of e-waste exposure in Guiyu, China found that

e-waste specifically affects women's morbidity/mortality, and fertility. McAllister et al. (2014) explain:

> Of the 14 general types of hazardous chemicals commonly found in e-waste, more than half affect women's reproductive and endocrine functions. Women exposed to environmental toxins may suffer from anemia, fetal toxicity, menstrual cycle irregularities, endometriosis, autoimmune disorders, and cancers of the reproductive system. Lead and mercury exposure within the first trimester of pregnancy may affect fetal development, resulting in potential neurobehavioral development problems, low birth weight, or spontaneous abortion and birth defects. The damage to reproductive function after several years of exposure to this pollution is irreversible. For many women, this damage has occurred before they even reach reproductive age (p. 172).

While those who handle e-waste directly are at the greatest risk, all of the residents in the surrounding environment can experience second-hand exposure from e-waste. For example, exposure to toxic fumes through air pollution increases when e-waste is burned, and can result in impaired neural development, skin damage, headaches, vertigo, nausea, chronic gastritis, and gastric and duodenal ulcers (Chen, Dietrich, Huo & Ho, 2010). Chemical residues from e-waste can also be introduced into homes from clothing and other materials, which can lead to long-term low-level exposure. Children are particularly at risk from this type of exposure because they are more likely to accidentally ingest these toxic substances (Park, Hoerning, Watry, Burgett & Mattias, 2017).

Transcorporeality

Environmental and health research shows that the effects of e-waste exposure can be invisible and indirect, but may still have a lasting impact on humans and nature. From a biocentric perspective, this is a very important aspect to consider about the future of e-waste, as it

highlights the interconnectedness between all organisms and ecosystems. This sense of interconnectedness is the crux of transcorporeality, proposed by Alaimo (2008), a theory that argues that humans are ultimately inseparable from nature.

Transcorporeality describes the ways that science, politics, and culture collide, while considering the closeness of the human body to the environment. Alaimo (2016) posits that we are "entangled with multiple material agencies, flows and processes that connect human bodies, animal bodies, ecosystems, technologies, and the wider world" (p. 17). What I like about Alaimo's approach is that she argues against the boundaries between humans, objects, and the environment, and presents a "posthumanist new materialism that does not begin with discrete objects, separated from the human subject, but instead begins from a material feminist sense of the subject as already part of the substances, systems, and becomings of the world" (p. 13).

Alaimo makes the case for material agency, that objects are not only autonomous actors, but are embedded with socio-cultural biases. However, she does not believe in personifying objects with human-like traits:

> I just can't drink the KoolAid here and believe that a cable experiences anything at all; nor do I find it useful—personally, intellectually, ethically, politically, or in any other way—to imagine what it is like to "be" a cable. I do wonder, however, what it is like to be a human imagining what it is like to be a thing (Alaimo, 2013, p. 15).

A central part of my thesis explores the ways that e-waste is entangled economically, politically, and spatially, with human experience. I argue that there is a limit to the effectiveness of facts and statistics as ways to talk about e-waste, because I think that it creates fear, and that fear exacerbates inaction. From the perspective of transcorporeality, I am prompted to think about

other ways of framing a conversation about e-waste. How can theory be made more acessible, and how can it provoke action?

Alaimo (2013) believes that a critical analysis of matter and materialism is an explicitly feminist pursuit, because it "proceeds from the recognition that the knower is simultaneously the 'subject' and the 'object' of inquiry" (p. 16). The subjects of my thesis are digital devices, and through collecting and examining discarded e-waste, I have begun to think of these devices in terms of their physical matter, and the significance of their tangible qualities.

Through Alaimo's transcorporeal lens, I can reframe my understanding of the lifecycle of e-waste as the lifecycle of matter and material elements. Alaimo (2010) also argues that material elements are already a part of who we–as humans–are, and are a part of our environment, even though they are "not natural" (p. 18). Alaimo makes the case that nature itself is not virtuous, and that a sentimental notion of the purity of nature should be rejected. The concept of transcoporeality can be operationalized through immersive technologies, as it blurs the lines between observer and observed.

Speculative Fabulation

Similar to Alaimo, in the *Cyborg Manifesto*, Haraway (1991) rejects the notion that there are innate, essential differences between biological organisms. Instead, she proposes a chimeric, monstrous, cyborg world of fusions between animal and machine. She argues that "late twentieth century machines have made ambiguous the lines between natural and artificial" (p. 152). She

dismisses overly romantic discourse that glorifies the innocence of nature, and the desire to return to a mythical Garden of Eden, as naive. She writes, "innocence, and the corollary insistence on victimhood as the only ground for insight, has done enough damage" (p. 157). I think this is very relevant as it allows a conversation about e-waste to move beyond the pedantry of assigning blame.

In *Staying with the Trouble*, Haraway (2016) outlines strategies for action, and offers ways to reconsider and reconfigure the relationships between nature, humans, and animals. She does not refer to our current time period as the Anthropocene, an epoch wherein humans have been the primary determinants of transformation upon the earth. According to this perspective, the future is bleak and calamitous because humans have exploited the world's natural resources, destroyed ecosystems, and as a result are on the brink of a global ecological disaster. Haraway urges us to move beyond the dichotomous traps of anthropocenic thinking, either that "technology will somehow come to the rescue of its naughty but very clever children", or that "the game is over, it's too late, there's no sense trying to make anything better" (p. 3).

Instead, Haraway conceptualizes our current time period as the Chthulucene, which describes our epoch as one in which the human and nonhuman are inextricably linked, and requires "sympoiesis": collective creation and organization. She advocates that we must "learn to stay with the trouble", which she describes as "redo[ing] ways of living and dying attuned to still possible finite flourishing, still possible recuperation" (p. 10). She argues that staying with the trouble of living and dying together (with plants and animals) on a damaged earth will provoke the kind of urgent responses that would allow us to build more liveable futures, while

recognizing that “we require each other in unexpected collaborations and combinations,…we become-with each other or not at all” (p. 4).

Like Alaimo, Haraway does not privilege human experiences over those of others, rather, she argues that humans are among the many creatures with and of the earth, collectively responsible for the trajectory of the future. She proposes “tentacular thinking” (p. 32) as a way of reimagining our current paradigm through the connections we have with other species. This approach moves beyond simply labelling the points of those connections, but thinks through how we are connected (e.g. symbiotically, parasitically). She employs a methodology of “speculative fabulation” (p. 10), to envision a possible future of animal-human genetic symbiosis over the next 400 years, or five generations.

Haraway’s process of speculative fabulation began at a writing workshop, where participants were collectively asked “to fabulate a baby, and somehow to bring the infant through five human generations” (p. 134). The first iteration, Camille 1, is born in 2025 and the last, Camille 5, dies in 2425. During this time the global human population continues to increase to a high of ten billion in 2100, before declining to three billion by 2400. This massive reduction in the overall number of human animals is initially made possible through a practice of birthing babies bonded with animal “symbionts” (p. 135). Camille 1 is born in symbiosis with a monarch butterfly, and later generations of Camilles become more deeply entangled with the monarchs, due to changes in technology, ecosystem, and culture. Haraway and her writing group hypothesized new patterns of “kinship, intimacy, and response-ability” (p. 100) as ways of understanding the relationships between species and their ever-changing environment.

Haraway's mission of "staying with the trouble" inspires much of my work. When thinking about the future of e-waste, I want to move beyond the dichotomous ideas of dystopian or utopian imagination. Rather, I propose through my prototype that, as global citizens and consumers of technology, we must acknowledge our participation and complicity in the production of e-waste, and accept responsibility for this involvement. Quite simply, we must make the best of what we have got, and recognize that we are permanently entangled in this predicament with other organisms. I argue that there is no distinction between humans and the environment, because the toxic contamination of our ecosystem is evident in our bodily health. Ultimately, I believe that there is no way out of this mess, but we must make this mess visible in order to address it.

Speculative fabulation provides a strong conceptual framework for my research, which can be actualized through a design methodology. There are many parallels between Haraway's process of hypothetical fabulation, and the practical techniques of speculative making, for example through critical design. The following section examines the creative techniques that I used to transfer my abstract ideas into visual works.

Methodology

To create my prototypes, I employed a critical design methodology. Critical design is a research through design methodology, popularized by Dunne and Raby, that is used to create hypothetical products, services, and scenarios of an alternative future. In my project, I utilized a subset of critical design, known as design futurescaping, to create images, objects, and videos to speculate on the future of e-waste. I wanted to create an immersive experience where the problem of e-waste became extreme and unavoidable, and I was interested in seeing how audiences responded to this visual confrontation.

A challenging aspect of my project was trying to figure out how to make my prototype relevant and understandable to viewers who do not know, or perhaps even care, about e-waste. There is a large body of research that suggests that visual and sensory information can be more effective in provoking changes in people's behaviour than text can. Ahn et al. (2014) investigated this idea further, by testing audience reactions to information about deforestation–either through text, two-dimensional visuals, or immersive technologies–and they found that technologies like augmented reality and virtual reality can be even more impactful than planar images in provoking a reaction and changes in behaviour. Thus, to create a more accessible visual experience in my project, I utilized different immersive effects.

To build my final prototype, I drew from the science fiction-inspired approaches of design futurescaping, and experimented with the technological capabilities of 360 video.

Critical Design

Critical design is a form of research that leverages art and design practices to make consumers more critical of their everyday lives. It is intended to challenge consumers' perceptions of how their lives are mediated by assumptions, values, and behavioural norms that are inscribed through everyday, affirmative designs (Dunne & Raby, 2013). Critical design takes an embodied approach, where the representation of something in a tangible or visible form is central to its process. However, as Barzdell (2013) explains, "the primary outcome is knowledge, not an aesthetically pleasing design product."

Critical design is a methodology that reveals potentially hidden agendas and explores alternative design values (Malpass, 2016). For example, Dunne and Raby (2013) created a multi-medium installation, *United Micro Kingdoms*, that speculated on an unspecified future, where England would be divided up into four micro-kingdoms: Digitarian; Commune-nuclearist; Anarcho-evolutionist; and Bioliberal (Figure 9). The micro-kingdoms were conceived by the designers as "glimpses into potential futures for our own society that allow us to debate their desirability" (UMK, 2018). Each micro-kingdom has its own political ethos, economic system, and way of life. They illustrated this fictional scenario through a series of texts, visual representations, and objects, that allowed viewers to gain a multidisciplinary, comprehensive understanding of this new, proposed society.

Figure 9. United Micro Kingdoms map.
Reprinted from *United Micro Kingdoms* (UMK, 2018).

By presenting audiences with the hypothetical products, services, and systems of an alternative future, these designs challenge them to imagine the ways in which reality could be different. The critical process is in designing a solution that is not comforting or comfortable for the user, but still relatable to them. The outcome should make the user think, and evaluate how they are implicated by the design. It should prompt questions like, "Could this happen? Is this the future?"

Design Futurescaping

Design futurescaping is a type of critical design that speculates about the future. It is a hybrid practice, pioneered by Anab Jain and her Indian-Anglo design studio, Superflux. At Superflux, the tools and insights of critical design are deployed in a form of foresight production, through a process of creating artefacts, videos, and speculative scenarios to explore future possibilities (Jain, Ardern, & Pickard, 2011).

For example, Superflux created an immersive installation called *Mitigation of Shock* that imagines the year 2050 when droughts and hurricanes have altered human eating habits. Jain (2017) explains:

> Based on climate data projections, we are exploring a future where the Western world has moved from abundance to scarcity. We imagine living in a future city with repeated flooding, periods with almost no food in supermarkets, economic instabilities, broken supply chains. What can we do to not just survive, but prosper in such a world? What food can we eat?

By drawing from science fiction and storytelling/worldbuilding approaches, and extrapolating from media, and contemporary trends in climate change, the Superflux team created a London apartment of the future (Figure 10). Using salvaged e-waste materials, they built functioning "food computers", such as an automated fogponics machine that can grow tomatoes (Jain, 2017).

Figure 10. Artefacts from Mitigation of Shock installation.
Screenshot from *Why We Need To Imagine Different Futures* (Jain, 2017).

Jain (2017) argues that "the disconnect between scientific, data driven predictions of global warming, and the lack of immediately visible signs creates a space of cognitive dissonance, its implications unsettling and ominous." By prototyping design solutions to scenarios that are likely to happen in the near future, Jain hopes that individuals can create and share the tools, methods, and materials to respond to such situations. Jain believes that visualizing these scenarios can help to mitigate the shock of climate change, prompt action towards capacity building, and provoke individuals to do something, rather than to be complacent.

Design futurescaping has many parallels to Haraway's call to stay with the trouble. The intention behind Jain's *Mitigation of Shock* project echoes the methodology of speculative fabulation as a process to confront and problem-solve about a specific issue. Using these concepts and works as inspiration for my prototyping process, I had to consider the "trouble" of e-waste. I first needed to understand the scope and the tangibility of the issue that I was investigating in order to conceptualize a visual response or solution to it. Once I gained more familiarity with the material of e-waste in its current state, I was then able to speculate on its future.

Prototyping

Through my prototyping process, I explored the affordances of different technologies and mediums, with the intent to create experiences of immersion between the viewer and my work. I first investigated the materiality of the e-waste that I collected, and experimented with sculpture, augmented reality, and 3D video to highlight the formal and spatial qualities of these objects. This process helped me to gain more insight into the objects themselves, and to understand the transcorporeal connections between the e-waste and a larger ecosystem of matter.

Then, using a design futurescaping methodology, I cultivated a narrative that expressed the philosophical underpinnings of my work: the interconnectedness of humans and the environment, and the need to "stay with the trouble" in order to tackle problems like e-waste. I created a scenario that speculated on the future of e-waste, and leveraged the experimental, immersive nature of 360 to communicate these ideas visually.

Material Exploration

The first stage of my process of speculating about the future of e-waste was to investigate the materiality of e-waste. From July 2017 until March 2018, I collected e-waste from my friends and colleagues, and put out a call on Facebook to solicit any discarded electronics from the local community in Toronto (Appendix A). In the first six months of the call, I received over 100kg of e-waste, including printers, a mini power generator, a CRT television, reels of wires, a dozen

smartphones, and a handful of floppy disks. I was curious to know where these objects came from, where they were made, by whom, and what sort of life they had before being thrown away.

I arranged the e-waste objects on an empty white table, as if they were specimens collected from a crime scene. I then photographed each object in a forensic style, as well as in a more creative way, to show the textures, colors, bumps, scratches, and wear and tear from use (Figure 11).

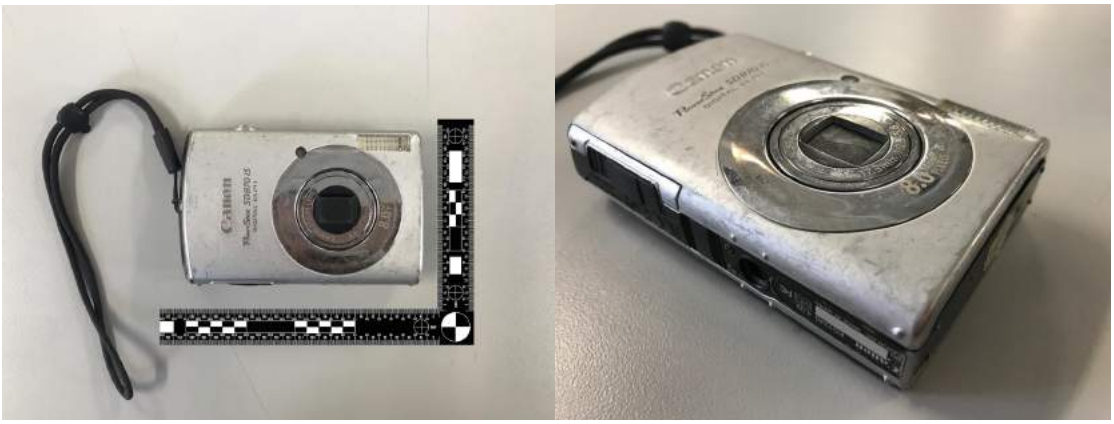


Figure 11. Photo of e-waste, Samaa Ahmed (2017).

The objects had been defined as waste by their original users, and were donated to this project as useless garbage. In this way, the objects were dead. However, they continued to have a life, beyond their first user's needs, and also carried the markings of the ways that they had been used in the past. From a transcorporeal perspective, the objects had agency. They were political objects, with material histories, and in this way, they were alive.

Over the course of this project, my e-waste pile/collection became somewhat of a spectacle among my peers. Often I would come to find new pieces of e-waste placed on my desk by my

classmates, or receive messages from friends asking if I was still collecting e-waste, and if I would be interested in more. They were glad to donate their e-waste if it could "have a purpose."

Each time I have shown the e-waste objects that I have collected, the phones in particular elicit a strong response, usually along the lines of "I can't believe someone threw that out! It looks fine!" By making my collected e-waste visible to others, the issue became more literal and immediate for them. It is difficult to conceptualize what e-waste looks like until you are confronted with it, and it is easy to dismiss e-waste as a bunch of useless garbage. In reality, however, people throw away perfectly "nice" and potentially salvageable objects, and do so at an alarming rate and frequency.

I kept my collected e-waste on my desk in the Digital Futures studio, and with time, became a touchpoint/site of e-waste disposal myself. I stored the e-waste in plastic and cardboard boxes, to stop it from becoming an eyesore and a distraction. I quickly realized the irony of this, that despite my project's aims (to create an intervention that makes e-waste visible) I was hiding the e-waste, too.

Over the past six months, I have rearranged and reorganized my e-waste collection several times. I first filtered out the objects that could still be used, for example computer mice that still worked and extension wires that were in good condition, and used them myself or gave them to others. I also offered my classmates devices that they could dismantle and repurpose in their own projects, such as audio cables from discarded speakers. I then sorted the objects by size and functionality, collecting multiples together. I considered the colors, textures, and materials of the

objects, and thought about ways that I could create art and design pieces out of them. I thought about projecting onto them, or making sculptures out of them. At least twice I got overwhelmed with the sheer excess of remaining waste, and wanted to throw everything out (recycling it responsibly, of course).

Handling the e-waste was a multi-sensory experience. My e-waste pile was vast, and continually growing. It made me think about the rapidity with which technology is consumed and then disposed. I found it frustrating that people would throw away so much good stuff, but then empathized with the fact that technology changes so quickly that everything becomes obsolete within a matter of years.

As part of this project, I tried to use my old MacBook White, bought in 2009, which I used all throughout my undergraduate degree. Although I had not used it since 2013, it seemed to be in good enough condition: it still switched on, and loaded the Desktop properly. However, its operating system was so old and outdated, that no web browser was able to support it, so I was not able to even use the Internet to check my emails. Its processor was incredibly slow, and while I could open simple Word documents and photo files, I could not open new types of files, like 360 videos. This made me realize that even if I wanted to use my old electronic devices, and prolong upgrading as long as possible, that I would be very limited in accessing contemporary media. Unfortunately, to be thrifty in this regard is to be excluded from the zeitgeist of current information.

Sculpture

The next stage of my prototyping process was to create speculative artefacts from e-waste using a design futurescaping methodology. I speculated on what sorts of technological devices would emerge if e-waste objects spontaneously blended with one another. To experiment with this idea, I created a deconstructed, non-functioning sculpture using discarded wires, microchips, a fan, a broken keyboard, a mouse, and a video game joystick. I named my sculpture the *Speculative Computer*, as it resembled a traditional computer (Figure 12). However, I added enhanced potential functionalities, compared to a traditional computer, by creating new combinations of and connections between parts.

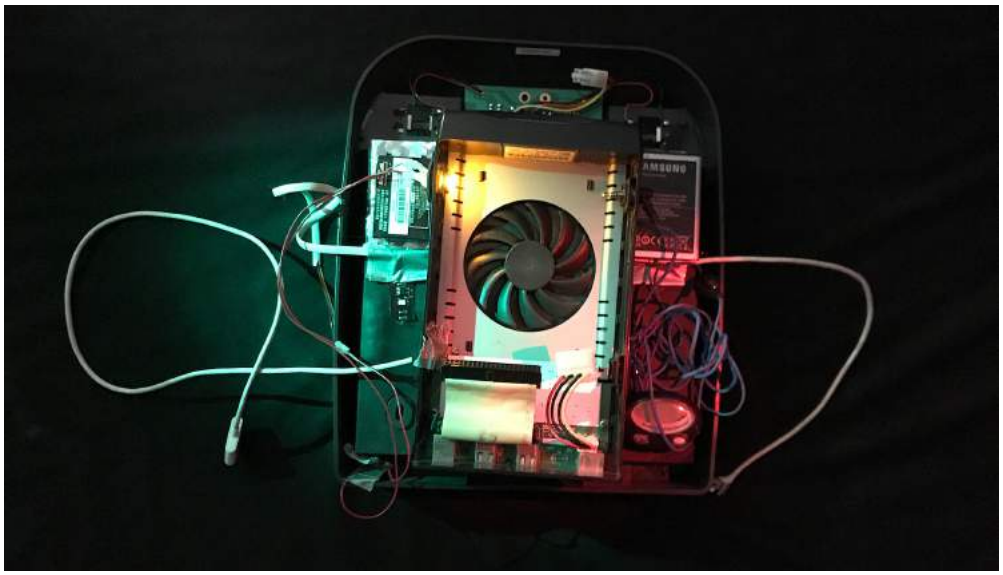


Figure 12. Photo of *Speculative Computer* processor, Samaa Ahmed (2018).

The *Speculative Computer* was made up of three parts: a screen, a processor, and input controllers. Although none of the parts were connected to a power source, I embedded LEDs

within the different parts of the sculpture to add as a light source, and also to make it seem more animated.

I installed this sculpture in the Digital Futures studio, and observed how my peers interacted with it. Most started by tapping on the keyboard, clicking the mouse, or moving the joystick. These actions were similar to how most people first interact with a computer. However, once they realized that the sculpture was non-functional, they stopped interacting with it as a practical machine, but as a larger, conceptual work. They noticed that some of the microchips belonged to mobile phones, while another small lens belonged to a camera. They began to ask questions, and make observations, about the mismatch of parts. For example, one person asked whether this new computer could run independent of a power source, and another suggested that it could function as a modular machine that users could reconfigure to their preferences. It was interesting to create connections between these observations and my previous research, such as the suggestion of modularity as a function of the *Speculative Computer* and the modular cell phone in Project Ara.

Receiving feedback from this piece helped me to structure my approach for how to communicate abstract ideas in future iterations of my prototypes. I realized that I did not have to be explicit in stating my concepts or what I wanted the viewers to take away from the experience. Rather, the viewers approach the work with their own biases and ideas in mind, so more ambiguity in the piece allows more opportunity for interpretation.

Augmented Reality

During the summer of 2017, I participated in a prototyping course at the Canadian Film Centre (CFC). In this course, I developed the first interactive iteration of my thesis prototype. For the scope of this initial prototype, I wanted to map the spatial relationships of e-waste: for example, from purchasing a device in a retail environment, to using the device in daily life, to disposing of the device, to following its journey to an e-waste processing center. I created six videos to map with six of the stages in the lifestyle of e-waste, using original footage and found footage. I wanted to create an immersive storytelling experience that made an explicit connection between the object and its history.

To create this experience, I decided to use an augmented reality (AR) technology. AR is a semi-immersive technique that overlays new content over an existing environment using digital tools. I used a QR code, similar to a barcode, to create the AR interaction, and the e-waste objects to create a tangible user interface (TUI). The TUI allowed users to scan QR codes on the back of e-waste objects, using their smartphones, and then to watch a short video montage of landscapes in the different stages of the e-waste lifecycle (Figure 13). I wanted users to experience the simultaneous death and liveliness of the objects when interacting with them. The aim of this prototype was to draw attention to the impacts on the environment, human and ecological health, and the larger economies of e-waste; especially pointing out our role as consumers in the West, where the lifecycle of our objects does not begin and end with our use.

Figure 13. Diagram of AR user flow, Samaa Ahmed (2017).

User Flow:

1. User approaches table with e-waste objects.
2. User chooses an e-waste object.
3. User opens QR scanner on their phone, or on laptop/phone provided.
4. User scans QR code on e-waste object.
5. Link to video appears on phone or laptop screen.
6. User clicks "Play" and watches video.

In my user testing of this prototype, I was able to model the interaction on a very small scale, using my laptop as both the scanner and the projection screen, and AR provided a great starting point to explore immersion through technology. In the prototype presentation, users could choose to scan the objects using their phones, or my laptop. The difference was only in the scale of the visualization/video that was played. The personalization of the phone screen evoked one type of feeling/experience and spoke to the hyper-individualization of technology, whereas the large projection spoke to the culture of mass production and the shared problem of e-waste. I received positive feedback from this session, and was offered some useful suggestions to develop further in my subsequent prototypes, particularly on how to create a more immersive experience for the viewer.

3D Video

An important piece of feedback that I received from the first prototyping session was to try to create a more immediate sense of immersion between the viewer and the digital content, and to more explicitly convey the impact of e-waste, beyond numbers. In an attempt to address this, I created a video of myself dumping some of my e-waste into a box. I positioned the camera on the edge of a table, so that it had an aerial view of the box. I then slowly dropped e-waste objects into the box in a repetitive motion.

I used Ahn et al. (2014)'s research as inspiration for this video. Their research found that visual representations are more effective than text in making audiences feel implicated by the content of the information presented to them. Thus, in my piece, I wanted the viewers to respond to the duration of the piece, as well as the sounds of e-waste being collected in a box. The video was shown in real time, which helped to communicate the scale of the e-waste, due to the speed at which I was able to handle each of the objects and fill the box. The sounds of the e-waste falling into the box, and colliding with other objects, also helped to communicate the immensity and volume of the waste, as well as its physical impact upon the space.

In post-production, I created two stereoscopic versions of the video, one in cyan and the other in red, which I then layered on top of each other with a slight offset. The result was an anaglyph 3D effect video, where ghostly wires become visible for a brief moment before being covered by more e-waste (Figure 14). I also created a pair of red-cyan 3D glasses for viewers to wear.

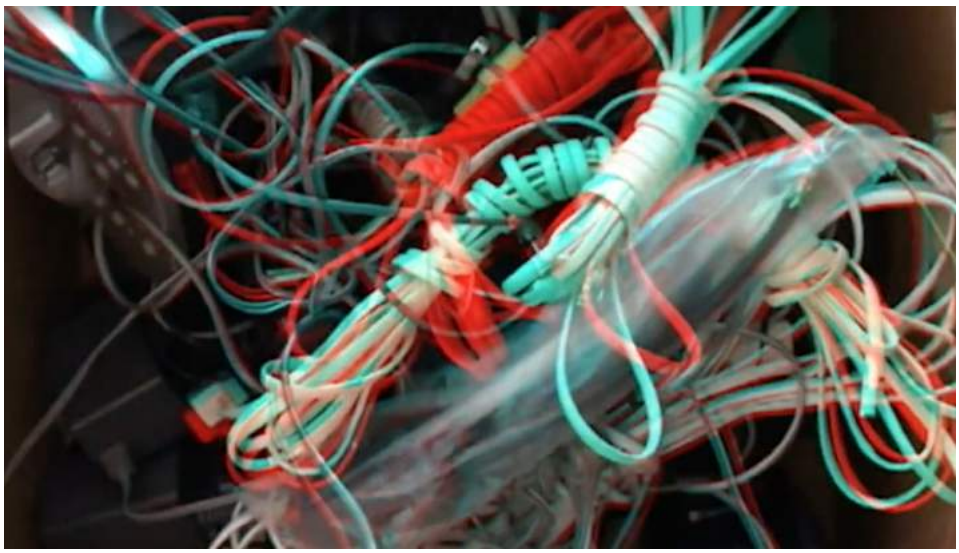


Figure 14. Screenshot from 3D video, Samaa Ahmed (2017).

In my second prototype test, I projected this 3D effect video onto a wall, floor, and a ceiling. Viewers could watch the video using the 3D glasses, which created a 3D view of the objects through the polarizing filters. Using video as the medium for this piece was a comment on the temporality of e-waste, and projecting on different surfaces was meant to evoke a sense of volume, scale, and immersion.

At this stage of my prototyping process, I had not yet decided on using 360 video to create an immersive experience. While the 3D effect video was more effective in conveying depth than the AR prototype, there was still a barrier of sorts between the viewer and the imagery, as the projected surface acted as a screen. Additionally, at this point of my process, I had not moved beyond exploring the materiality of the objects; I had not yet crafted a narrative nor created a scene for futurescaping.

Speculation

The next stage of my process was to cultivate a narrative. I employed Haraway's process of speculative fabulation to brainstorm three future generations–approximately 100 years–of human relationships to e-waste and then build the world. I created a mindmap of the key characteristics of each of these epochs, including some of the most urgent questions related to social power, environmental issues, and ethical concerns in each scenario (Appendix B).

The process of speculating on the different phases of the future of e-waste was helpful in working through some of the most important insights in my research, and also in identifying the most salient issues to address in my final prototype. This process also helped me to re-contextualize my work within a global context, and emphasize the inextricably connected difficulties that we all must face together. After this initial brainstorm, I realized that I wanted my prototype to have a point of view beyond the binary of good or bad, utopian or dystopian, as I believe that the future of e-waste will be a combination of both.

Instead of speculating on the future of the world, and humanity in general, I decided to focus my final prototype on how landscapes will be transformed by e-waste. My prototype explores the potential lifecycle of the matter and material elements of e-waste within an organic environment. I see e-waste, and its resultant toxicity, as a catalyst for organismal mutations. I speculate upon the ways in which what is considered "natural" will change over time, and how non-organic e-waste will mutate wildlife, ecosystems, and environments. Those mutations may be monstrous,

as described by McAllister et al. (2014) and Chen et al. (2010), or they can be vibrant and beautiful, a symbolic garden of infinite possibility.

Using Jain's methodology of design futurescaping, I created a storyboard for a 360 video to speculate on the future of e-waste. In this video I consider the following questions: will the spread of e-waste be curtailed? What are the social and environmental changes that will occur due to the spread of e-waste? How will humans and other organisms adapt to these changes? In what ways can humans intervene to make the future of e-waste less bleak? Essentially, how can consumers stay with the trouble of e-waste, and how can viewers of this piece feel encouraged, rather than defeated, by this futurist rendering?

Final Prototype

Planning

For my final prototype, I chose to create an immersive experience using 360 video as a medium, and shot all of my videos for this project using a Samsung Gear 360 camera (2017 model). My concept was to use my speculative scenarios to guide the visuals of a world that was overwhelmed by e-waste. While designing for my 360 experience, I wanted the viewer to feel a sensory overload, and to feel submerged in a pile of e-waste.

While 360 cinema is still a new medium, Murray (2016) outlines a few techniques to optimize the functionalities of 360 video when shooting a scene. Firstly, she emphasizes, "the focus of VR design is not the camera frame, but the embodied visitor." She suggests that 360 videos should not use transitional cuts, nor should the frame of the video be adjusted during the same scene, to minimize the contrast between real life and the video for the viewer. For that same reason, she also proposes that 360 videos should not include voice-overs, text overlays, or background music, however I decided that some of these effects would be useful in my piece as they help the narrative to progress.

Murray provides helpful guiding principles that challenged me to think differently about how to create the kind of experience I envisioned in virtual space. For example, without cutting between scenes or zooming in on specific parts of a frame, it is difficult to direct a viewer's attention. However, this type of effect could be achieved instead using ambient, spatial sound. Because 360

immersive videos are viewer-directed, I also had to let go of a bit of control, and accept the fact that not everyone will focus on exactly what I want them to, nor will they have the exact experience that I design. That is both an advantage and disadvantage of such an experimental medium.

To plan my 360 video prototype, I drew inspiration from King's (2015) documentary work, where he captured slow, but continuous movement, of trash. In his piece, the ongoing stream of trash became sort of hypnotizing, and lulled the viewer into a sense of calm. However, in my piece I did not want the viewer to feel calm, rather I wanted them to feel unsettled and uncomfortable by the increasing layers of e-waste. An affordance of the technology that allowed me to achieve this effect is the ability to manipulate scale and 3D perspectives using 360 video.

Figure 15. Spherical view of 360 video scene, Samaa Ahmed (2018).

The lens of a 360 camera functions as the eye-level of a person, so by putting the camera underneath a pile of e-waste, and then showing the final piece in a VR headset, I could create the feeling that the person viewing the 360 video had shrunk and was standing inside the e-waste pile. This effect is different from a traditional video because the screen that the viewer is experiencing it through is attached to their head, and allows them to navigate around the video, in a spherical space (Figure 15).

Process

While I had a clear idea of what I wanted to shoot, it was difficult for me to storyboard the scenes while taking into account a full, 360, 3D environment that would be captured in each scene. Storyboarding for 360 and VR is very different than for traditional video, because there are less camera angles available (or, perhaps too many), and the scope of what is included in a shot is quite random unless the scene is completely controlled. The 360 environment can be very unpredictable, and the footage that is captured in the gap between the two lenses–which eventually gets stitched together–often gets distorted. Though it is possible to account for the stitch in the planning stages, and approximate how much of the scene will be affected, the full effect can only be seen once the scene has been shot and merged. The most seamless scenes to stitch are those with large blocks of similar colours and smooth textures. Scenes with lots of patterns and details are more noticeably uneven and disjointed when stitched.

For my first 360 video test, I decided to shoot in a public park, because I wanted to capture a natural landscape. Unexpectedly, this proved to be a very difficult task. Firstly, I had not thought

about how to exclude myself from the shot. Unlike a traditional camera, where you can stand behind the lens, a 360 shot captures everything in its vicinity, including the camera-person. Because I was in a public place, I did not want to leave my camera alone during the shoot. So, to try to not be in the shot, I stood behind a tree. However, as Figure 16 shows, I was included in the shot. Secondly, I had not thought about how to exclude my tripod from the shot. A 360 camera shoots what is underneath it, which means that it cannot be placed on a stand or surface with a large base, because it would be included in the shot. Interestingly, from a transcorporeal perspective, including all of these elements in the shot would be considered inevitable, and constructive, as it demonstrates the interconnectedness of all bodies.

Figure 16. Still from 360 video test, Samaa Ahmed (2017).

From that experience, I learned that I should try to minimize the factors outside of my control, so I decided to shoot in a closed set as much as possible. Some of my scenes required being outdoors, but I tried to limit the unpredictable elements in the scene by shooting in my garden. The next scenes that I shot were more carefully planned, and shot inside an empty critique room

at school, and inside a broken air conditioning unit. There was much less movement in these shots, which made it easier for me to control, but also potentially made for less interesting visuals. I decided to go for a more minimal aesthetic, and decided that I could add or enhance elements digitally in postproduction.

The standard format for my scenes was to create an environment, and then to shoot from within it. The first environment that I created was very cluttered, and I placed the camera within the clutter, to make the viewer feel claustrophobic as more e-waste was added around them (Figure 17). The second environment was much more sparse, using only LEDs to represent e-waste. I wanted to emphasize the contrast between visibility and hiddenness of e-waste through this shift. The third environment was a nature scene, with LEDs randomly dispersed around the camera. The LEDs were meant to represent the implicit trace of e-waste, even after the physical clutter of e-waste was cleared from view.

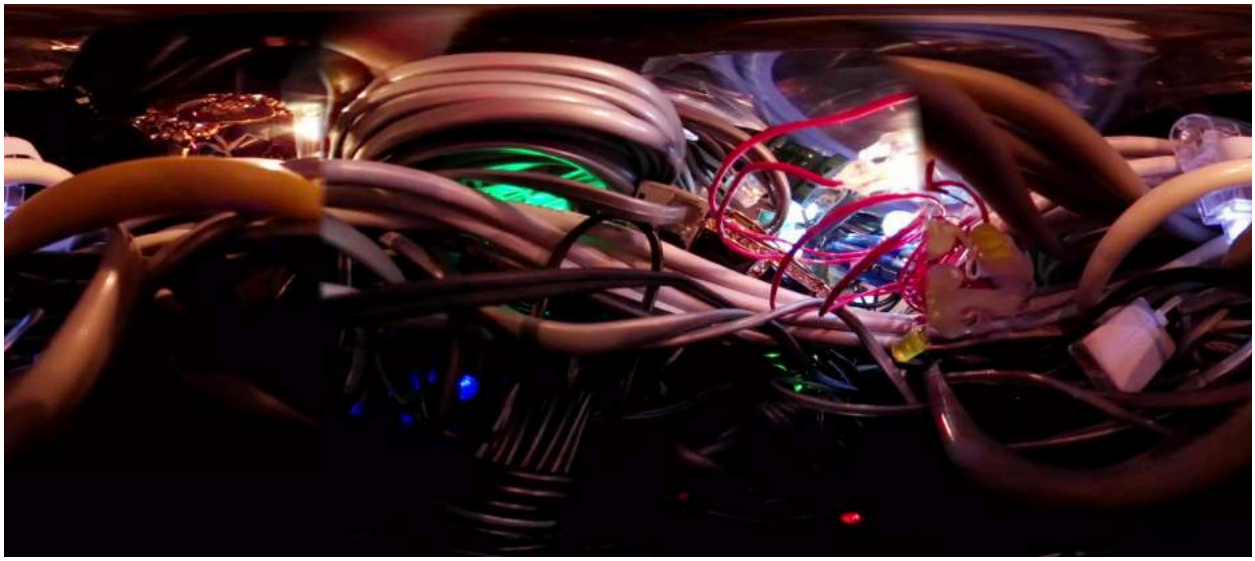


Figure 17. Still from 360 video test, Samaa Ahmed (2017).

After shooting my scenes, I uploaded them onto my laptop, and stitched the raw files together using Samsung's Gear 360 application. I compiled and edited the scenes of my video together in Adobe Premiere Pro. In the first iteration of my video there were several errors, such as the stand of my 360 camera being visible in the shot. However, at this stage I was more interested in whether I was able to convey the conceptual aspects of my project through 360 video, rather than in refining the video.

Figure 18. Photo of user navigating through 360 video on touchscreen, Mudit Ganguly (2018). Reprinted with permission.

I tested my video prototype with my classmates, to investigate how effective the 360 video was in creating an immersive environment, and whether the–admittedly abstract–narrative was understandable. I only had one Google Cardboard headset, so I also used an iPad tablet and a large touch-screen to show the video on, where viewers could navigate through the video using their fingers (Figure 18). I received feedback that the combination of visuals and the motion of

moving through the scene was similar to the feeling of rifling through layers of material or objects. I thought that this was a potentially interesting additional layer of immersion, and thought about whether to show some of my 360 videos on touch screens of different sizes during the thesis exhibition, which would allow audiences to experience differences in scale, proportions, and immersiveness (Appendix E).

The Trace

The 360 video is narrated by a voiceover, using text adapted from the Preamble of *Zeroes + Ones* (Plant, 1997, Appendix D). In the first scene of the 360 video, the viewer is submerged within the pile of e-waste, and is able to rummage around through it. The visuals in this scene are similar to the images of gleaning and rummaging captured in *The Gleaners and I* (Varda et al., 2002). The process of sorting, collecting, and using material in the agricultural context, by the gleaners, is not dissimilar to the process of harvesting and dismantling e-waste in dumps all over the world (Journeyman Pictures, 2016; Vaatika, 2013; Fedele, 2012; SBS Dateline, 2011).

Varda's film captures the poetics of scavenging, and reveals its political and social significance. I think that this practice, of salvaging material that has been discarded, echoes Alaimo's notion of transcorporeality. Alaimo (2013) argues, "it is how objects are entangled—economically, politically, and substantially across bodies, ecosystems, and built environments—that matters, not how each object exists in isolation" (p. 18). The entangled wires and digital objects in this scene serve as a metaphor for the potential future of e-waste. They represent a cluster of possibilities and infinite variations of how they may be (re)used, (re)configured, and

(re)contextualized. Additionally, instead of editing out the camera wires and tripod in the final video, I decided to leave them in, to reflect the complexity and connectedness of materiality and the environment.

As the viewer navigates through the scene with their headset, they are able to see the unexpected transformations and hybridizations of the e-waste. The mix of wires and LEDs conjure an image of a jungle, or a wild landscape, which emphasizes the relationship of these objects, and our selves, to nature. While the viewer is immersed within the scene, I hope that they too feel entangled by the matter and transcorporeality of e-waste, and I would like them to consider questions of ownership and responsibility to these objects. I would like them to not only see that the waste and toxicity surrounds them, but that it is also within them.

The final scene of the video was set in a garden, with the glow of LED lights visible on the natural elements in the shot. The dispersion of light in this scene represents the unknown, unresolved aspects of my speculative rendering. I refer to this notion of uncertainty as The Trace.

The Trace symbolizes the unknown extent of the damage of e-waste, as well as an unresolved stance towards e-waste. The Trace represents that which is still invisible about e-waste, including its toxicity, but also the long-term political and economic impact that it will have on a global scale. The Trace characterizes the inescapable, but currently undetermined, consequences of e-waste. From a postcolonial perspective, The Trace serves as an acknowledgement that the consequences of the spread of e-waste will depend upon geographic location, and that certain communities will suffer or prosper more than others.

The Trace also signifies an attitude of disruption, to show that the future of e-waste is still abstract and undefined. I argue that presenting an explicitly bleak rendering of the future would create feelings of apathy in viewers, because it would seem that there was nothing that they could do to change the outcome. Therefore, I wanted to ensure that my video ended on an ambiguously hopeful note. Instead of creating a pessimistic, doom-laden vision of the future, I wanted this scene to show that we, as consumers and citizens, have the agency to create and imagine the future. This may mean that we can enact more conscious behaviours around our consumption of digital devices, or that we can lobby for more accessible resources and more robust policies about e-waste.

Discussion

In this research, I was able to leverage the affordances of digital techniques and technologies to create a layered, immersive visual experience that speculates on the future of e-waste. My final prototype consists of a 360 video and a sculptural installation. A common visual thread between both works/mediums is that of LEDs. Drawing from Yates' sculptures (2014), the LEDs act as a metaphor for The Trace of e-waste: how the toxicity and consequences of e-waste are long-lasting. I chose to use LEDs to represent this because I was able to make the trace visible through light. In the final scene of the 360 video, the LEDs are reflected on the grass and plant leaves, and take on a bioluminescent quality.

Reflections

While researching reports, policies, and media for this project, I noticed that the prevailing attitude towards e-waste was overwhelmingly cynical. Most of the texts and articles that I read on the topic outlined, in great detail, how terrible the situation is, and created a profound sense of pessimism and hopelessness, as if to suggest that it is beyond salvation. At points during this project, consuming all of this negative information overwhelmed me. I questioned what the point of this project was, if we were all going to inevitably die, and that all of our attempts to rectify the situation were futile. I felt apathetic, as many people do in similar situations, encountering a problem that seemed impossible to solve.

However, as a feminist, I refused to let this nihilistic attitude take over my work. I had to decenter my ego, and my inherently anthropocentric perspective, from the project. The point of my project is to show the interconnectedness of all species, and to show that humans and non-human actors alike are affected by e-waste. I want to emphasize that the future of e-waste is yet undetermined, and that by speculating and creating visualizations about it, we can be more prepared and confident in creating the kind of future we want.

I hope that people leave my exhibit asking more questions about e-waste, and with a desire to educate themselves further on this issue. To address one of the initial aims of this research, which was to better inform people about e-waste, I created a resource sheet that viewers can take with them after the exhibition (Appendix G). This resource sheet includes a brief overview of the facts and statistics about the global spread of e-waste, and a summary of key international and domestic legislation about e-waste. It also includes information about where to recycle e-waste locally (in Toronto), and avenues to advocate for more robust e-waste policy (e.g. contacting the City of Toronto, or participating in international forums like StEP). I hope that this resource list allows people to feel more knowledgeable about the issue of e-waste, and more confident in advocating for change.

Further Directions

During the time that I have been working on this project, there have been new developments in creating more environmentally friendly electronics and technology, which may provide an avenue to reduce e-waste production. For example, scientists have created organic and

biodegradable semiconductors (Steeno, 2015; Derouin, 2017), water-soluble, dissolvable microchips (Zyga, 2015), as well as electronic components from cornstarch (ACS, 2017). Researchers have even repurposed natural materials, such as fish scales and fungi, into energy nanogenerators and rechargeable batteries (Lumb, 2016; ACS, 2016). Most recently, biochemical engineers have even grown hybridized, nanobionic plants that naturally glow in the dark (Trafton, 2017, Figure 19).

Figure 19. Bioluminescent plants.
Reprinted from *Engineers create plants that glow* (Trafton, 2017).

It is impressive to see the ingenuity in these developments, as they have the potential to completely reframe how we think about technology, and concepts like energy. Currently, we think of electronic energy as a human-made, finite resource, but if scientists have created technologies to hack naturally occurring processes, like plant or fungi growth, to extract their energy, the potential is limitless. Using biodegradable semiconductors, water-soluble microchips,

or fish scales as batteries, can entirely change the way that digital devices are designed, how they are used, and who has access to them.

As we look to the future, technology provides some practical solutions to tackle the propagation of e-waste. Art and design also have important roles to play in sparking ideas, and motivating people to change their attitudes towards e-waste. Creative and immersive technologies can help to create simulations to imagine alternative futures and modes of being. It will be very interesting to see how virtual reality and 360 video will be used in the future, not only as artistic or expressive outlets, but also potentially as problem-solving and policy tools.

References

ACS (2016). *Fungi recycle rechargeable lithium-ion batteries. ACS.* Retrieved 8 March 2018, from https://www.acs.org/content/acs/en/pressroom/newsreleases/2016/august/fungi-recycle-rechargeable-lithium-ion-batteries.html.

ACS (2017). *Degradable electronic components created from corn starch. ACS.* Retrieved 8 March 2018, from https://www.acs.org/content/acs/en/pressroom/presspacs/2017/acs-presspac-april-19-2017/degradable-electronic-components-from-corn-starch.html.

Ahmed, S. (2016). *The Global Cost of Electronic Waste. The Atlantic*. Retrieved 3 August 2017, from https://www.theatlantic.com/technology/archive/2016/09/the-global-cost-of-electronic-waste/502019/.

Ahn, S. J., Bailenson, J. N., Park, D. (2014). Short- and long-term effects of embodied experiences in immersive virtual environments on environmental locus of control and behavior. *Computers in Human Behavior*, 39, 235-245.

Alaimo, S. & Hekman, S. (2008). Trans-corporeal Feminisms and the Ethical Space of Nature. In *Material Feminisms*. Bloomington: Indiana University Press.

Alaimo, S. (2010). *Bodily Natures: Science, Environment, and the Material Self.* Bloomington: Indiana University Press.

Alaimo, S. (2013). Thinking as the Stuff of the World. *O-Zone: A Journal of Object-Oriented Studies*, 1, 13–21.

Alaimo, S. (2016). *Exposed: Environmental Politics and Pleasures in Posthuman Times.* Minneapolis: University of Minnesota Press.

AMP (2018). *About. AMP.* Retrieved 8 February 2018, from https://qamp.net/about/.

antttttttttt (2008). *Assembly Line Circuit Breaker Factory of the World.* [Video File]. Retrieved 16 January 16, from https://www.youtube.com/watch?v=fn62gcoOE3Q.

Baldé, C.P., Forti V., Gray, V., Kuehr, R., Stegmann, P. (2017). *The Global E-waste Monitor - 2017*, United Nations University (UNU), International Telecommunication Union (ITU) & International Solid Waste Association (ISWA), Bonn/Geneva/Vienna.

Barzdell, S. (2013). *Utopian Design? Feminism and Critical Design*. [Video File] Retrieved 8 September 2017, from http://bcrw.barnard.edu/videos/utopian-design-feminism-and-critical-design/.

Bayou With Love (2018). *About.* Retrieved 8 February 2018, from https://bayouwithlove.com/about.

Bisschop, L. (2014). Illegal E-waste Transports: Exploring their Harmfulness, Scale, Social Organization and Governance. In T. Spapens, R. White & M. Kluin, *Environmental crime and its victims.* Dorchester: Dorset Press.

Buni (2018). *Fabrication Lab. Buni.or.tz.* Retrieved 8 February 2018, from http://buni.or.tz/programs/.

Chen, A., Dietrich, K., Huo, X. & Ho, S. (2010). Developmental Neurotoxicants in E-Waste: An Emerging Health Concern. *Environ Health Perspect*, 114(9), 431-438.

Churu, J. (2015). *Innovative designer takes e-waste to another level. BiztechAfrica.* Retrieved 8 February 2018, from http://www.biztechafrica.com/article/innovative-designer-takes-e-waste-another-level/10614/.

Davies, C. (2004). Virtual Space. In, Penz, F., Radick, G. & Howell, R. *Space: In Science, Art and Society*. Cambridge University Press.

de la Peña, N. (2015). *The Future of News? Virtual Reality*. [Video File]. Retrieved 7 August 2017, from https://www.ted.com/talks/nonny_de_la_pena_the_future_of_news_virtual_reality.

Derouin, S. (2017). *Flexible, organic and biodegradable: Stanford researchers develop new wave of electronics. Stanford News.* Retrieved 8 March 2018, from https://news.stanford.edu/2017/05/01/flexible-organic-biodegradable-new-wave-electronics/.

Dunne, A., & Raby, F. (2013). *Speculative Everything*. Cambridge: MIT Press.

Elias, J. (2010). Labor and Gender. *Oxford Research Encyclopedia of International Studies.* Retrieved 8 Feb. 2018, from http://internationalstudies.oxfordre.com/view/10.1093/acrefore/9780190846626.001.0001/acrefore-9780190846626-e-250.

Elmer-Dewitt, P. (2016). *Apple: What Liam the Robot Can't Do*. *Fortune.* Retrieved 8 February 2018, from http://fortune.com/2016/03/27/apple-robot-liam-disassembly/

Elson, D., & Pearson, R. (1981). 'Nimble Fingers Make Cheap Workers': An Analysis of Women's Employment in Third World Export Manufacturing. *Feminist Review*, (7), 87-107.

Engler, M. (2004). *Designing America's Waste Landscapes*. Johns Hopkins University Press.

Fedele, D. (2012). *E-Wasteland.* [Video File]. Retrieved 20 December 2017, from https://www.youtube.com/watch?v=yUCoToorc9M.

Frazzoli, C., Orisakwe, O. E., Dragone, R. & Mantovani, A. (2010). Diagnostic health risk assessment of electronic waste on the general population in developing countries' scenarios. *Environmental Impact Assessment Review*, 30(6), 388-399.

Furtado, J. (1989). *Ilha das Flores* =: Isle of Flowers. Brazil.

Gabrys, J. (2011). Digital Rubbish Theory. In *Digital rubbish: a natural history of electronics*. Ann Arbor: University of Michigan Press.

Graham, J. (2016). *Why 360 video is the next big thing in tech. USA Today.* Retrieved 8 February 2018, from https://www.usatoday.com/story/tech/2016/01/08/why-360-video-next-big-thing-tech/78499508/.

Ghani, F. (2016). *The woman turning rubbish into homes in Pakistan. Al Jazeera.* Retrieved 8 February 2018, from http://www.aljazeera.com/indepth/features/2016/06/woman-turning-rubbish-homes-pakistan-160629181246015.html.

Ghosn, R. & Jazairy, E. H. (2015). *Geographies of Trash*. Actar Publishers.

Goldsmith, B. (2009). *Trash or treasure? Upcycling becomes growing green trend. Reuters.* Retrieved 8 February 2018, from https://www.reuters.com/article/us-trends-upcycling-life/trash-or-treasure-upcycling-becomes-growing-green-trend-idUSTRE58T3HX20090930.

Goleman, D. (2009). *Ecological intelligence: how knowing the hidden impacts of what we buy can change everything.* New York: Broadway Books.

Griffin, A. (2017). *White plastic MacBook declared 'obsolete' by Apple, killing it off entirely. The Independent.* Retrieved 8 February 2018, from http://www.independent.co.uk/life-style/gadgets-and-tech/news/macbook-apple-white-plastic-obsolete-iphone-3g-pro-unibody-polycarbonate-a7712861.html.

The Guardian. (2011). *Digital debris: The toxic path of electronic waste.* [Video File]. Retrieved 7 August 2017, from https://www.theguardian.com/environment/video/2011/jun/14/toxic-electronic-waste.

Haraway, D. J. (1991). A Cyborg Manifesto: Science, Technology, and Socialist-Feminism in the Late Twentieth Century. *Simians, Cyborgs and Women: The Reinvention of Nature*, 149-181.

Haraway, D. J. (2016). *Staying with the Trouble: Making Kin in the Chthulucene*. Duke University Press.

Harman, G (2002). *Tool-Being: Heidegger and the Metaphysics of Objects*. Peru, IL: Open Court.

Hester, H. (2016). *Technically Female: Women, Machines, and Hyperemployment. Salvage.zone.* Retrieved 8 February 2018, from http://salvage.zone/in-print/technically-female-women-machines-and-hyperemployment/.

Huggan, G. & Tiffin, H. (2006). *Postcolonial Ecocriticism: Literature, Animals, Environment*. Routledge, New York.

Jain, A (2017). *Why We Need To Imagine Different Futures*. TED Talk. [Video File]. Retrieved 1 January 2018, from https://www.ted.com/talks/anab_jain_why_we_need_to_imagine_different_futures.

Jain, A., Ardern, J., & Pickard, J. (2011). Design Futurescaping. Blowup: The Era of Objects. *Blowup Reader,* 3, 6-14.

Jerry DIT. (2018). *You and Jerry Can. Youandjerrycan.org.* Retrieved 8 February 2018, from http://youandjerrycan.org/.

Jomo, K. S. (2013). *Industrialising Malaysia: Policy, Performance, Prospects.* Routledge, New York.

Jones, R. (2016). *What Is Modular Tech And Should You Believe The Hype?. T3*. Retrieved 8 February 2018, from https://www.t3.com/features/what-is-modular-technology-and-should-you-believe-the-hype.

Journeyman Pictures. (2016). *The Toxic E-Waste Trade Killing Pakistan's Poorest.* [Video File] Retrieved 7 August 2017, from https://www.youtube.com/watch?v=axYKPbr9_MA.

Kalan, J. (2014). *Is e-waste an untapped treasure?. BBC.* Retrieved 8 February 2018, from http://www.bbc.com/future/story/20140218-why-your-old-tech-holds-treasure.

King, JP. (2015). *What is it Like to Be a Landfill?: A Fictocritical Guide to the Department of Discard Culture, Compassionate Phenomenology, and Surrealist Ethnography*. Masters thesis, OCAD University.

Koslow, T. (2016). *West African WoeLab is Creating 3D Printers and Robots From E-Waste. 3DPrint.com.* Retrieved 8 February 2018, from https://3dprint.com/132350/woelab-ewaste-printer/.

Lateral Office (2017). *States of Disassembly: Speculations on Architecture as part of the E-Waste Cycle. Lateral Office*. Retrieved 27 February 2018, from http://lateraloffice.com/filter/Work/STATES-OF-DISASSEMBLY-2017.

Lines, K. & Garside, B. (2016). Clean and inclusive? Recycling e-waste in China and India. *International Institute for Environment and Development (IIED).* Retrieved 8 February 2018, from http://pubs.iied.org/pdfs/16611IIED.pdf.

Lora-Wainwright, A. (2016). The trouble of connection: e-waste in China between state regulation, development regimes and global capitalism. In, Harper, K., Vaccaro, I. and Seth Murray, D. (eds.) *The Anthropology of Postindustrialism: Ethnographies of Disconnection*, 113-131. Routledge, New York.

Lumb, D. (2016). *Indian researchers recycle fish scales into energy nanogenerator. Engadget.* Retrieved 8 March 2018, from https://www.engadget.com/2016/09/06/indian-researchers-recycle-fish-scales-into-energy-nanogenerator/.

Lyons, K. (2016). *Only a third of UK consumers' plastic packaging is recycled*. *The Guardian*. Retrieved 8 February 2018, from https://www.theguardian.com/environment/2016/nov/21/only-a-third-of-uk-consumer-plastic-packaging-is-recycled.

Malpass, M. (2016). *Critical Design in Context: History, Theory, and Practices.* Bloomsbury, London.

McAllister, L., Magee, A., & Hale, B. (2014). Women, E-Waste, and Technological Solutions to Climate Change. *Health and Human Rights Journal*, 16(1), 166-178. Retrieved 8 February 2018, from https://cdn2.sph.harvard.edu/wp-content/uploads/sites/13/2014/06/McAllister1.pdf.

Milk, C. (2015). *How virtual reality can create the ultimate empathy machine*. [Video File]. Retrieved 10 February 2018, from https://www.ted.com/talks/chris_milk_how_virtual_reality_can_create_the_ultimate_empathy_machine.

Mohanty, C. T. (2003). *Feminism without Borders: Decolonizing Theory, Practicing Solidarity*. Duke University Press.

Murray, J. (2016). *Not a Film and Not an Empathy Machine. Immerse.* Retrieved July 24 2017, from https://immerse.news/not-a-film-and-not-an-empathy-machine-48b63b0eda93.

Nakamura, L. (2014). Indigenous Circuits: Navajo Women and the Racialization of Early Electronic Manufacture. *American Quarterly,* 66(4), 919-941. The Johns Hopkins University Press.

Osibanjo, O. (2015). Gender and E-waste Management in Africa. *Gender Heroes: from grassroots to global action*. Secretariats of the Basel, Rotterdam, Stockholm Conventions, 18-20.

Ottaviani, J. (2015). *E-waste Republic. Interactive.aljazeera.com.* Retrieved 8 February 2018, from https://interactive.aljazeera.com/aje/2015/ewaste/index.html.

Park, J.K., Hoerning, L., Watry, S., Burgett, T. & Matthias, S. (2017) Effects of Electronic Waste on Developing Countries. *Advances in Recycling and Waste Management*, 2 (2), 128, 1-6.

Parikka, J. (2011). *Medianatures: The Materiality of Information Technology and Electronic Waste*. Open Humanities Press, Living Books About Life series.

Paterson, M.J., Blanchfield P.J., Podemski, C., Hintelmann, H.H., Gilmour, C.C., Harris, R., Ogrinc, N., Rudd, J.W.M., & Sandilands, K. (2006). Bioaccumulation of newly-deposited mercury by fish and invertebrates: an enclosure study using stable mercury isotopes. *Canadian Journal of Fisheries and Aquatic Sciences*, 63, 2213-2224.

Pellow, D. (2007). *Resisting global toxics: transnational movements for environmental justice*. Cambridge: MIT Press.

Plant, S. (1997). *Zeroes + Ones: Digital Women + The New Technoculture*. Doubleday, New York.

Pongrácz, E. & Pohjola, V. J. (2004) Re-defining waste, the concept of ownership and the role of waste management. *Resources, Conservation and Recycling*, 40(2), 141-153.

Reisinger, D. (2015). *Is modular technology the next 'it' trend?*. *Fortune*. Retrieved 8 February 2018, from http://fortune.com/2015/09/07/modular-technology-business/.

Rucevska, I et al. (2015). *Waste Crime – Waste Risks: Gaps in Meeting the Global Waste Challenge.* United Nations Environment Programme. GEO 6 Europe Chapter 2. Retrieved 8 February, from http://web.unep.org/ourplanet/september-2015/unep-publications/waste-crime-waste-risks-gaps-meeting-global-waste-challenge-rapid.

Rujanavech, C., Lessard, J., Chandler, S., Shannon, S., Dahmus, J., & Guzzo, R. (2016). *Liam - An Innovation Story*. Retrieved 8 February 2018, from https://www.apple.com/environment/pdf/Liam_white_paper_Sept2016.pdf.

Saeed, A. (2013). *Dangerous labour: The little known 'e-waste' phenomenon. Dawn.com.* Retrieved 7 August 2017, from https://www.dawn.com/news/1032967.

Sierzputowski, K. (2015). *Kenyan Artist Digs Through Electronic Refuse and Found Metal to Create Dazzling Sculptural Eyewear. Colossal*. Retrieved 8 August 2017, from http://www.thisiscolossal.com/2015/07/eyewear-from-found-trash-cyrus-kabiru/.

SBS Dateline. (2011). *E-waste Hell.* [Video File] Retrieved 7 August 2017, from https://www.youtube.com/watch?v=dd_ZttK3PuM.

Steeno, J. (2015). *A new kind of wood chip: collaboration could lead to biodegradable computer chips. WISC News.* Retrieved 8 March 2018, from https://news.wisc.edu/a-new-kind-of-wood-chip-collaboration-could-lead-to-biodegradable-computer-chips/.

StEP (2018a). *Business Plan Calculation Tool for Manual E-waste Dismantling Facilities. Step Initiative*. Retrieved 8 February 2018, from http://www.step-initiative.org/business-plan-calculation-tool-for-manual-e-waste-dismantling-facilities.html.

StEP (2018b). *Step Supervisory Committee - Step 2014. Step Initiative*. Retrieved 8 February 2018, from http://www.step-initiative.org/step-supervisory-committee.html.

Trafton, A. (2017). *Engineers create plants that glow. MIT News*. Retrieved 8 March 2018, from http://news.mit.edu/2017/engineers-create-nanobionic-plants-that-glow-1213.

UMK (2018). *United Micro Kingdoms.* Retrieved 19 February 2018, from http://unitedmicrokingdoms.org.

Ungerleider, N. (2013). *This African Inventor Created A $100 3D Printer From E-Waste. Fast Company.* Retrieved 8 February 2018, from https://www.fastcompany.com/3019880/this-african-inventor-created-a-100-3-d-printer-from-e-waste.

Uzun, F. (2017). *"Very Frustrating Mexican Removal" An immersive 360° verbatim documentary*. Masters thesis, OCAD University.

Vaatika. (2013). *E-waste in India.* [Video File] Retrieved 7 August 2017, from https://vimeo.com/72891290.

Vallauri, U. (2009). Beyond E-waste: Kenyan Creativity and Alternative Narratives in the Dialectic of End-of-Life. *International Review Of Information Ethics,* 11*,* 20-24.

Varda, A., Bruzdowicz, J., Ciné Tamaris, & Zeitgeist Films. (2002). *Les glaneurs et la glaneuse =: The gleaners and I*. New York: Zeitgeist Video.

Vital, A. (2008). Toward an African Ecocriticism: Postcolonialism, Ecology, and Life & Times of Michael K. *Research in African Literatures*, 39(1), 87-106.

Voice of America News. (2011). *E-Waste.* [Video File] Retrieved 7 August 2017, from https://www.youtube.com/watch?v=KZUiURkKHxc.

Walker, L. & Jardim, J. (2010). *Waste Land.* Canada: Entertainment One.

Welch, C. (2015). *Google delays its Project Ara modular smartphone until 2016. The Verge.* Retrieved 8 February 2018, from https://www.theverge.com/2015/8/17/9166667/google-project-ara-phone-delayed.

Wong, M. H., Wu, S. C., Deng, W. J., Yu, X. Z., Luo, Q., Leung, A. O., Wong, C. S., Luksemberg, W. J. & Wong, A. S. (2007). Export of toxic chemicals – A review of the case of uncontrolled electronic-waste recycling. *Environmental Pollution*, 149(2), 131-140.

Yates, B. (2014). *Electri-City Mountain*. [Video File] Retrieved 30 January 2018, from https://www.youtube.com/watch?v=bsFfJlYs2rw.

Zyga, L. (2015). *Water-soluble silicon leads to dissolvable electronics. Phys.* Retrieved 8 March 18, from https://phys.org/news/2015-01-water-soluble-silicon-dissolvable-electronics.html.

APPENDICES

Appendix A: Facebook Call Text

I want your old, broken, damaged, obsolete digital devices! I am creating an installation for my Master's thesis at OCAD about e-waste, and I need as much old tech junk as I can find! So I am looking for phones, computer/TV monitors, CPUs, mice, keyboards, batteries, wires, microchips, whatever! Please let me know if you have any stuff to donate - you would not be getting it back. I can pick stuff up from places that are downtown and TTC accessible, or you could drop your stuff at 205 Richmond St W! Thanks! PS I'll be collecting until March 2018.

Link to post: https://www.facebook.com/groups/147733739131986/

Appendix B: Speculative Fabulation Narrative

The first generation will begin in the near future, and will be somewhat optimistic in nature. This generation will be characterized by entrepreneurship and neoliberal values. The predominant attitude in this generation is that e-waste issues are the responsibility of individuals; that solutions will be developed by corporations (who will implement them for a profit), and that any interventions will be guided and regulated by the free market. The types of solutions to e-waste issues in this epoch may include creating e-waste design or architecture firms, that use e-waste as a construction material in buildings.

On the surface, this epoch seems to be utopian, but there are many deep issues that are being neglected. One of the biggest problems with this approach is that it does not confront the root cause of e-waste production because it does not challenge current systems of consumption or manufacturing. The solutions proposed in this epoch focus on the Global North, and making life easier for people in economically wealthy countries, but does not think about the consequences–and those who are excluded–in the Global South.

The second epoch imagines a more authoritarian time, where international organizations, such as the UN, have implemented policies to ban the global manufacture, purchase, and ownership of digital devices. This would likely be difficult to enforce, so it begs the questions of how this ban would be regulated. As an alternative, all digital devices would be owned by the state, and their use would be regulated through a centralized system–somewhat similar to libraries. However,

this would be unlikely to happen unless there is some, potentially covert, benefit for large companies and governments.

This epoch has both utopian and dystopian elements. The banning of all digital devices worldwide would cause a major cultural shift, where questions of ownership, accountability, and legality would come into play. In a sense, creating a regulated, centralized system to access digital devices would be egalitarian, and offer equity in opportunity for people of different social classes. However, there will be resistance to this sort of regulation, and alternative, subversive systems will emerge. Some of these systems may be innovative and help to develop new skills and capabilities that will have societal benefits. Other systems may be considered illegal, such as a black market of digital devices, which would lead to heavy policing and the criminalization of certain groups. Thus, even though there may be some favourable outcomes, such as the promotion of a more interdependent, cooperative culture, there will still be systemic problems related to power. The question remains, who will profit from this type of scenario?

The third epoch is explicitly dystopian. In this scenario, global environments and ecosystems have been destroyed due to toxicity from e-waste and other pollutants. Agricultural land has been spoiled, and there is a shortage of access to food and water. There are limited places in the world that are still habitable, and Canada is one of the few countries that still has access to natural resources. Many species of flora and fauna are already extinct, and human survival is in danger.

This generation is an experience of the worst case scenario, if action towards e-waste control is not taken. It is an extreme, catastrophic situation. It appears that there is no solution that can

reverse the negative consequences brought about by e-waste toxicity. In short, everything is doomed. Envisioning this last epoch, and imagining an apocalyptic scenario, was difficult. I wanted to find a loophole where the world would not have to end or be destroyed. I did not want to give up hope.

Link to mindmap:
https://atlas.mindmup.com/2018/02/c354adb015e911e8aee50369a4fe2df4/e_waste_worlds/index.html

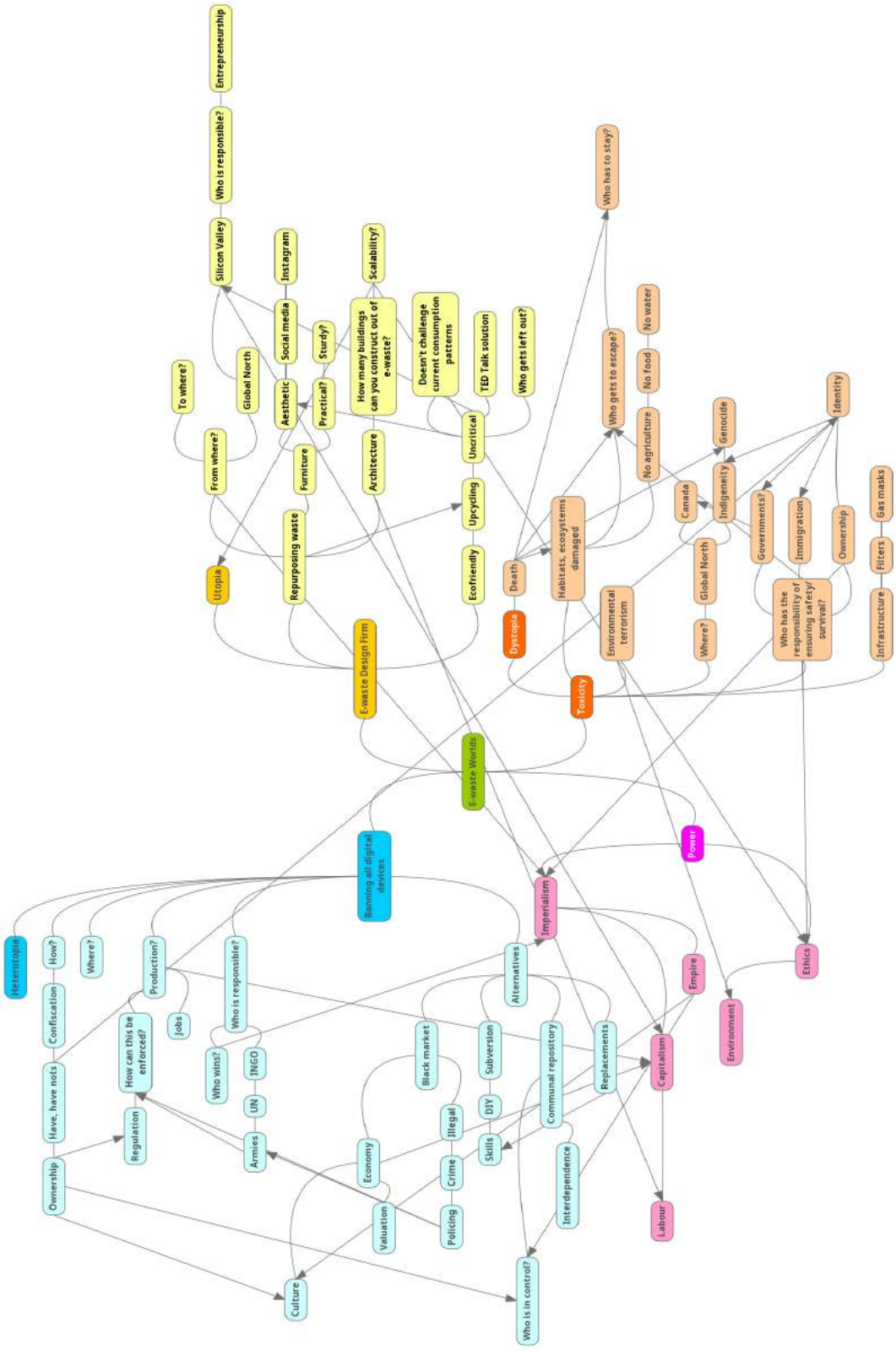


Figure 20. Speculative Fabulation: Three Generations Mindmap, Samaa Ahmed (2017).

Appendix C: Digital Debris Projection Piece

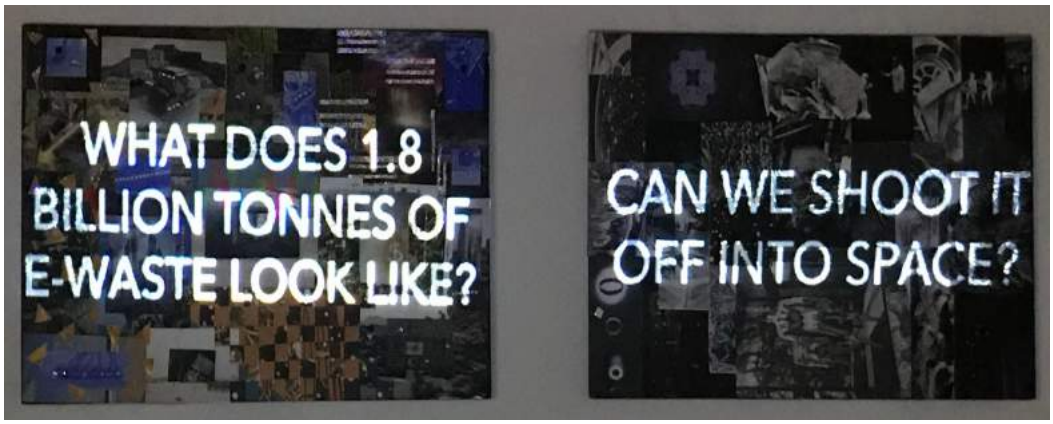


Figure 21. Digital Debris, Samaa Ahmed (2017).

Using the speculative scenarios as inspiration, I created an animated projection piece for my third prototype test. I projected questions and comments that I had received from the first two prototype presentations, as well as questions that I had come up with from my brainstorm, onto two abstract collages. The collages included images of digital devices, natural landscapes, and outer space, as well as metallic and reflective elements. Depending on the brightness of the space, and the color of the text, the projected questions varied in their legibility. I chose to obscure some parts of the text to emphasize the uncertainty of the topic, and also as a metaphor for the lack of awareness overall regarding e-waste.

I received positive feedback from this prototype test. My peers found the tangible installation to be an effective way to communicate the material, and the juxtaposition of the collage and the projection to be interesting. It was suggested that I should include elements of projection in my

final prototype exhibition. Another suggestion was to project directly onto the e-waste that I collected, and to show that in the exhibition space as well.

Appendix D: 360 Video Narrative Text

Adapted from Plant, S. (1997). Preamble. In *Zeroes + Ones: Digital Women + The New Technoculture*. Doubleday, New York.

To all intents and purposes, we disappeared.
Were we their parasites? Were they ours?

Either way, we found ourselves working as slave components of systems whose scales and complexities we could not comprehend.
We mutated to such an extent that we were unrecognizable to ourselves, banding together in units of a kind which, like everything, had been unthinkable before.
Only a few of us survived the break.

Conditions were so terrible that many of those who did pull through wished they had died.
There were rumors of betrayal and sabotage, whisperings of alien invasion and mutant beings from another ship.
Some said we had brought it on ourselves, that all our activity had backfired, that we had destroyed our environment by an accident we had provoked.

Noxious gases and thin toxic airs flooded our oceanic zone.
The climate changed. We couldn't breathe.
It grew terribly cold. Far too cold for us.

Everything we touched was poisonous.

And then something occurred to us.

If we had thought about it, we would have said it would go on forever, this fluent, fluid world.
We paid no attention: it was all for free.
It had been this way for tens, thousands, millions, billions of what were later defined as years.
Everything was there for the taking then.

Those were the days, when we were all at sea.
Species, sex, race, class: in those days none of this meant anything at all.
No parents, no children, just ourselves, strings of inseparable sisters, warm and wet, indistinguishable one from the other, gloriously indiscriminate, promiscuous and fused.
Folds and foldings, plying and multiplying, plicating and replicating.
Free exchanges, microprocesses finely tuned, polymorphous transfers without regard for borders and boundaries.

It seems like yesterday to me.

No generations. No future, no past.
An endless geographic plane of micromeshing pulsing quanta, limitless webs of interacting blendings, leakings, mergings, weaving through ourselves,
running rings around each other, heedless, needless, aimless, careless, thoughtless, amok.

There was nothing to hang on to, nothing to be grasped, nothing to protect or be protected from.

Insides and outsides did not count.

We had no definition, no meaning, no way of telling each other apart.

We gave no thought to any such things.

We gave no thought to anything at all.

Appendix E: Exhibition Design

My exhibition design is intended to create multiple layers of immersion. I was inspired by Ghosn and Jazairy (2015) to create a physical, translucent structure to show my preparatory work, and then have the final, 360 video available to experience within the structure. The physical structure is built out of wire cube organizers, in a U shape. The cubes are hollow, and have translucent plastic surfaces. A random assortment of the cubes are filled with e-waste, while others remain empty. In the gap on the floor between the organizers, the 3D video will be projected on the floor.

Either inside or next to the structure (depending on space availability) there will be two plinths with VR headsets and headphones available for audiences to watch the final 360 videos. The VR headsets will either be Google Cardboard or Samsung Gear. I will borrow, rather than purchase, these headsets so as to reduce the total e-waste footprint of my project and installation.

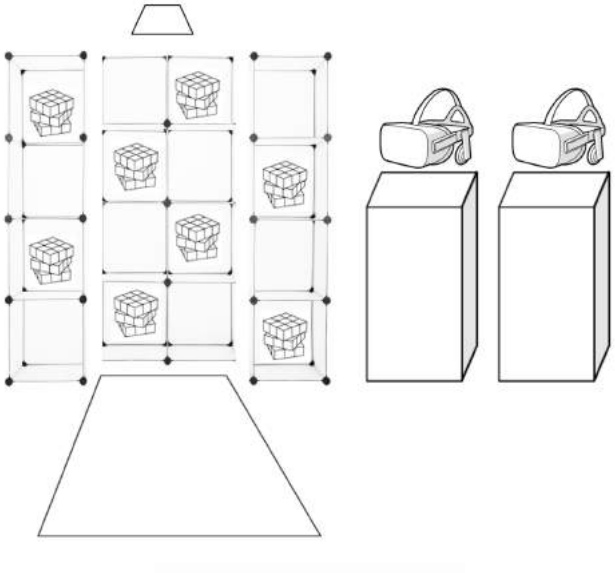
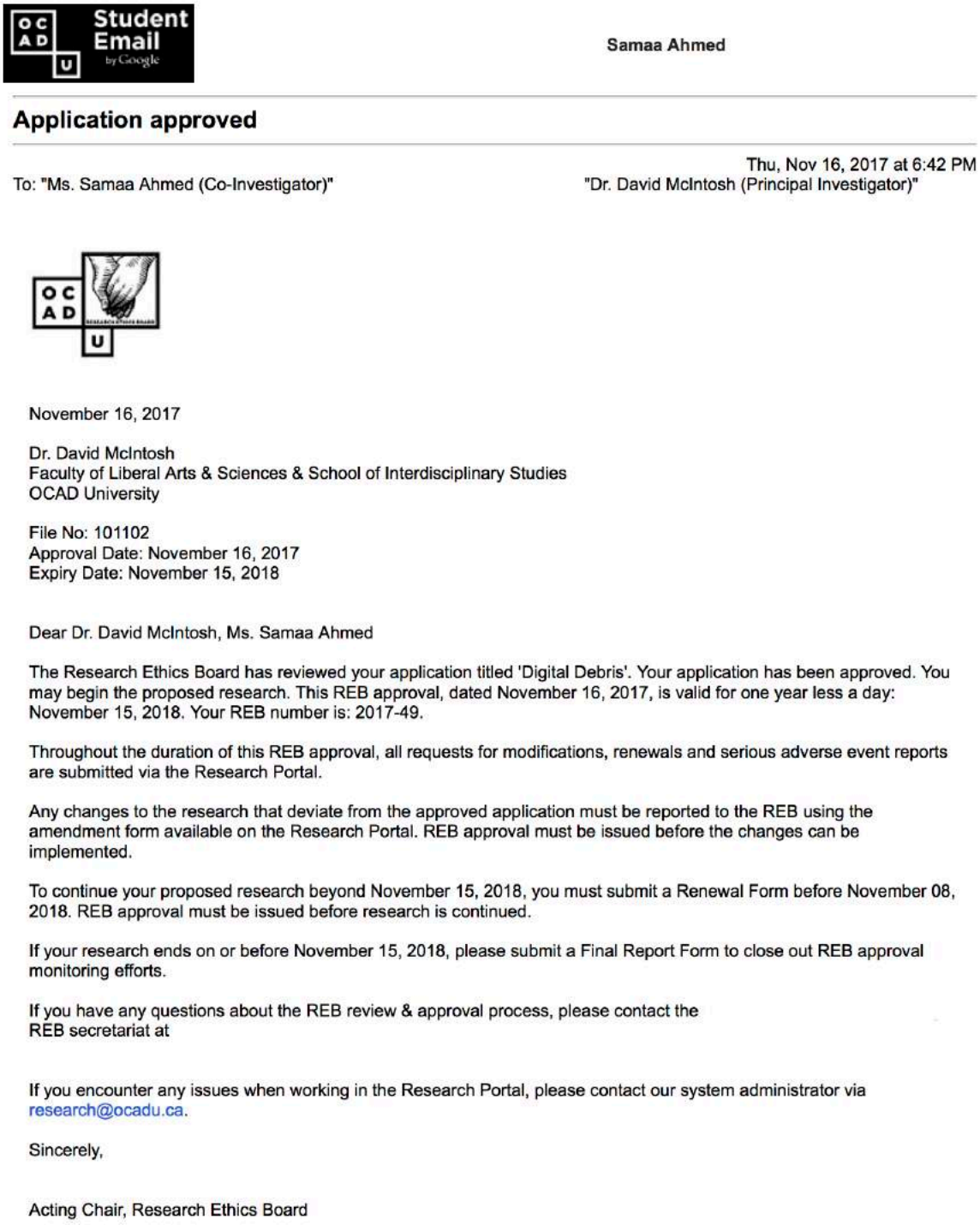


Figure 22. Exhibition design diagram, Samaa Ahmed (2018).

Appendix F: Research Ethics Board (REB) Approval Letter



Student Email by Google

Samaa Ahmed

Application approved

Thu, Nov 16, 2017 at 6:42 PM

To: "Ms. Samaa Ahmed (Co-Investigator)" "Dr. David McIntosh (Principal Investigator)"

November 16, 2017

Dr. David McIntosh
Faculty of Liberal Arts & Sciences & School of Interdisciplinary Studies
OCAD University

File No: 101102
Approval Date: November 16, 2017
Expiry Date: November 15, 2018

Dear Dr. David McIntosh, Ms. Samaa Ahmed

The Research Ethics Board has reviewed your application titled 'Digital Debris'. Your application has been approved. You may begin the proposed research. This REB approval, dated November 16, 2017, is valid for one year less a day: November 15, 2018. Your REB number is: 2017-49.

Throughout the duration of this REB approval, all requests for modifications, renewals and serious adverse event reports are submitted via the Research Portal.

Any changes to the research that deviate from the approved application must be reported to the REB using the amendment form available on the Research Portal. REB approval must be issued before the changes can be implemented.

To continue your proposed research beyond November 15, 2018, you must submit a Renewal Form before November 08, 2018. REB approval must be issued before research is continued.

If your research ends on or before November 15, 2018, please submit a Final Report Form to close out REB approval monitoring efforts.

If you have any questions about the REB review & approval process, please contact the
REB secretariat at

If you encounter any issues when working in the Research Portal, please contact our system administrator via research@ocadu.ca.

Sincerely,

Acting Chair, Research Ethics Board

Figure 23. Research Ethics Board Approval Letter

Appendix G: Resource Sheet

Digital Debris: Visualizing the Future of Global E-waste

E-waste includes personal devices, such as laptops and cell phones, to household items like refrigerators.

Almost any item with circuitry, electrical components, with power or battery supply, can be a potential source of e-waste.

Global E-waste Production

Source: The Global E-waste Monitor, 2017

E-waste Recycling in Toronto

The City of Toronto collects unwanted electronics for free to ensure they are disposed of safely, recycled and kept out of landfill. Electronic items can be put out on garbage day for pickup, brought to a Drop-off Depot or Community Environment Day or donated for reuse.

See: toronto.ca > Electronic Waste

Ontario Electronic Stewardship is an organization that operates an e-waste recycling program, and keeps e-waste out of landfills. They have several e-waste drop-off spots across the province.

See: ontarioelectronicstewardship.ca

Samaa Ahmed | samaa-ahmed.com | @wearivebeen

Figure 24. Resource Sheet (front), Samaa Ahmed (2018).

E-waste Resources

Basel Convention
http://www.basel.int

Commission for Environmental Cooperation
http://www.cec.org

Global E-waste Monitor
http://ewastemonitor.info

Solving the E-waste Problem (StEP) Initiative
http://www.step-initiative.org

Electronic Products Recycling Association
http://epra.ca

Electronics Product Stewardship Canada
http://epsc.ca

Recycler Qualification Office
http://rqp.ca

Waste Management, Ontario
https://www.ontario.ca/page/waste-management

Resource Recovery and Circular Economy Act, 2016
https://www.ontario.ca/laws/statute/16r12

Waste Diversion Act, 2002
https://www.ontario.ca/laws/regulation/040393

Canadian Environmental Protection Act, 1999
http://ec.gc.ca/lcpe-cepa

Figure 25. Resource Sheet (back), Samaa Ahmed (2018).

Appendix H: Exhibition Photographs

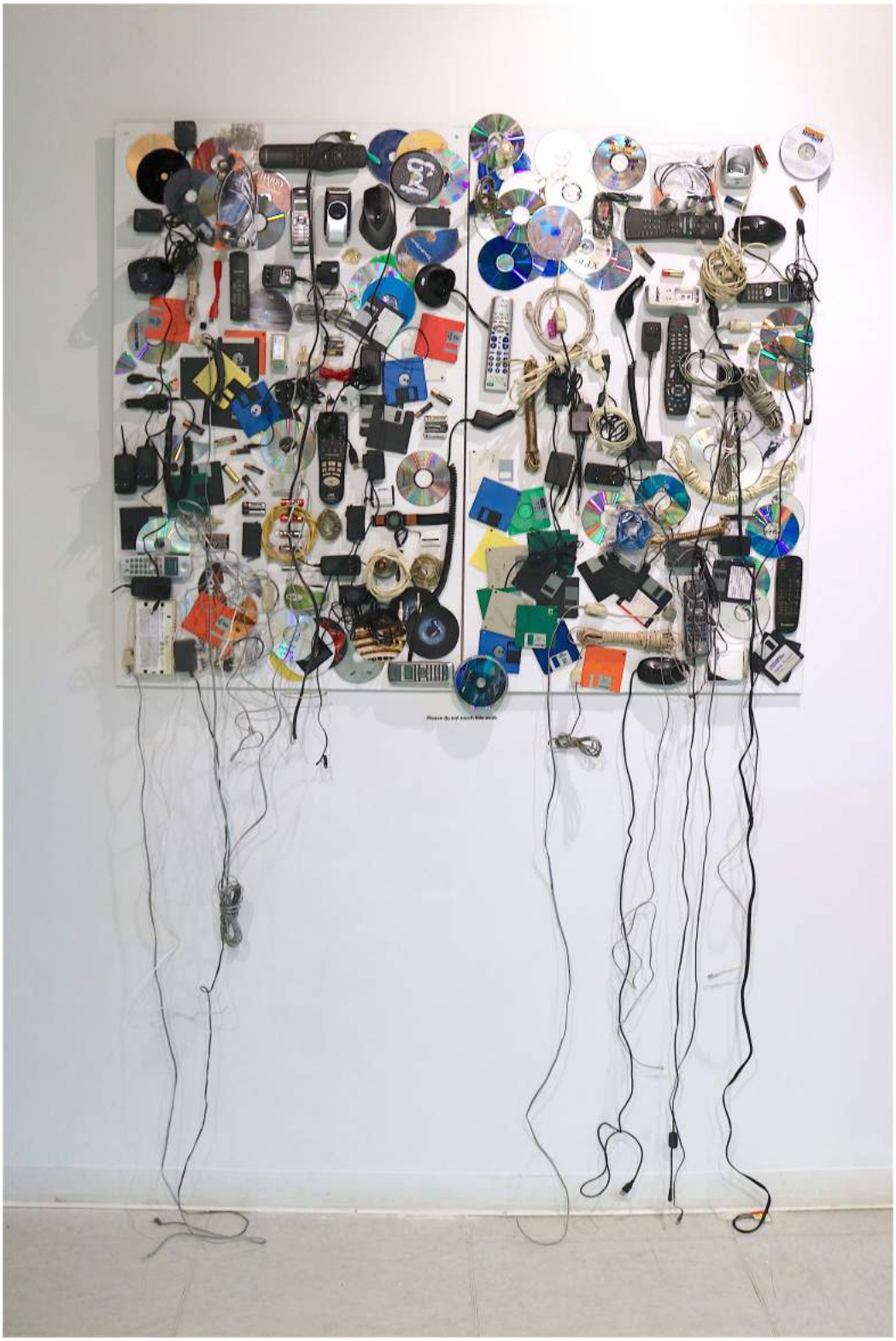


Figure 26. E-waste installation, Samaa Ahmed (2018).

Figure 27. Detail of e-waste installation, Samaa Ahmed (2018).

Figure 28. Detail of e-waste installation, Samaa Ahmed (2018).

Figure 29. Digital Debris installation at Diverge: Digital Futures Graduate Exhibition. Photo by Canadian Film Centre (2018), reprinted with permission.

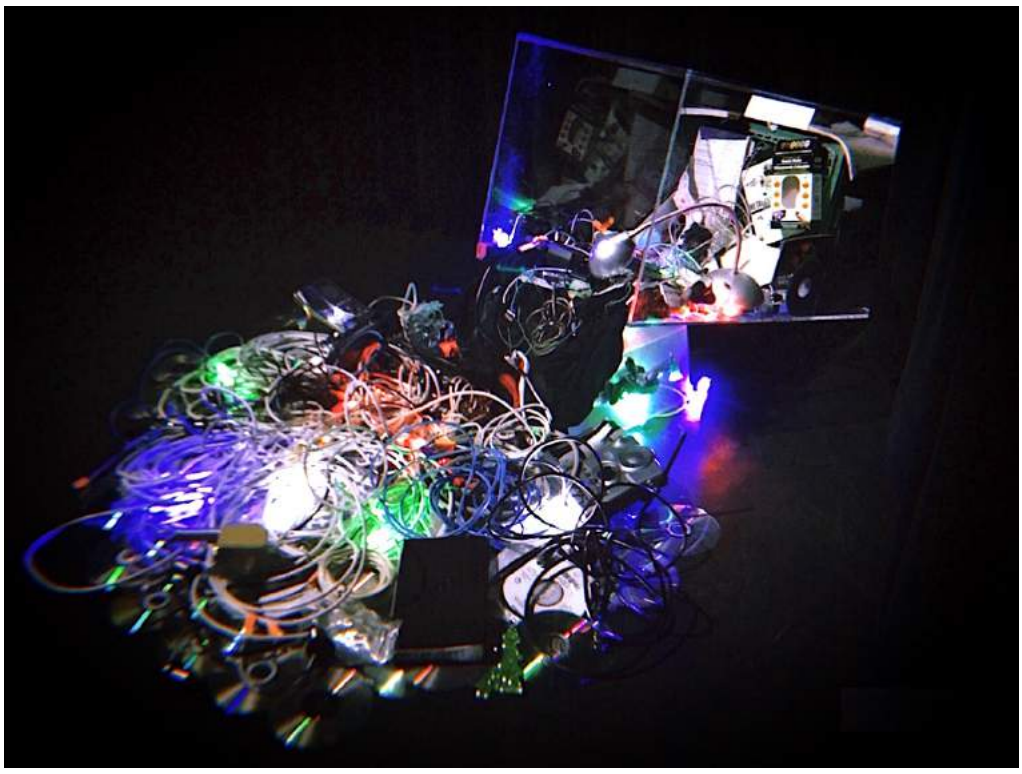


Figure 30. Digital Debris installation at GradEx 103, Samaa Ahmed (2018).